ROLE OF STERNOCLAVICULAR GRAFT FOR JOINT RECONSTRUCTION IN UNILATERAL TEMPOROMANDIBULAR JOINT ANKYLOSIS - A PROSPECTIVE STUDY

A Dissertation submitted in

partial fulfilment of the requirements

for the degree of

MASTER OF DENTAL SURGERY

BRANCH – III

ORAL AND MAXILLOFACIAL SURGERY

THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY

Chennai – 600 032

2010-2013

CERTIFICATE

This is to certify that **Dr. T. ROHINI**, P.G. Student (2010-2013) in the Department of Oral and maxillofacial surgery, Tamilnadu Government Dental College and Hospital, Chennai-600003, has done dissertation titled **ROLE OF STERNOCLAVICULAR GRAFT FOR JOINT RECONSTRUCTION IN UNILATERAL TEMPOROMANDIBULAR JOINT ANKYLOSIS - A PROSPECTIVE STUDY**" under our direct guidance and Supervision in partial fulfillment of the regulations laid down by The Tamilnadu Dr.M.G.R. Medical University, Chennai, for MDS, Branch-III, Oral and Maxillofacial Surgery Degree Examination.

GUIDE:

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DECLARATION

I, **Dr.T.ROHINI,** do hereby declare that the dissertation titled "**ROLE OF STERNOCLAVICULAR GRAFT FOR JOINT RECONSTRUCTION IN UNILATERAL TEMPOROMANDIBULAR JOINT ANKYLOSIS - A PROSPECTIVE STUDY"** was done in the Department of Oral and Maxillo Facial Surgery, Tamil Nadu Government Dental College & Hospital, Chennai 600003. I have utilized the facilities provided in the Government dental college for the study in partial fulfillment of the requirements for the degree of Master of Dental Surgery in the speciality of Oral and MaxilloFacial Surgery (Branch III) during the course period 2010-2013 under the conceptualization and guidance of my dissertation guide, **Prof. Dr. B. SARAVANAN** MDS, Ph.D. I declare that no part of the dissertation will be utilized for gaining financial assistance for research or other promotions without obtaining prior permission from the Tamil Nadu Government Dental College & Hospital. I also declare that no part of this work will be published either in the print or electronic media except with those who have been actively involved in this dissertation work and I firmly affirm that the right to preserve or publish this work rests solely with the prior permission of the Principal, Tamil Nadu Government Dental College & Hospital, Chennai 600 003, but with the vested right that I shall be cited as the author(s).

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DR.B.SARAVANAN,52/yrs working as **professor** in the Department of Oral & Maxillofacial surgery, at the college, having residence address at35/2,(17),Barathi salai,Triplicane,Chennai.600005. (herein after referred to as thePrincipal investigator')

And

Dr.T.ROHINI aged 29 years currently studying as **Post Graduate Student** in the Department of Oral & Maxillofacial surgery, Tamil Nadu Government Dental College and Hospital, Chennai-03 (herein after referred to as the 'PG Student and co-investigator').

Whereas the PG student as part of her curriculum undertakes to research on "**ROLE OF STERNOCLAVICULAR GRAFT FOR JOINT RECONSTRUCTION IN UNILATERAL TEMPOROMANDIBULAR JOINT ANKYLOSIS - A PROSPECTIVE STUDY"**for which purpose the Principal Investigator shall act as principal investigator and the college shall provide the requisite infrastructure based on availability and also provide facility to the PG student as to the extent possible as a Co-investigator

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Witnesses **Student Guide**

1.

2.

ACKNOWLEDGEMENT

I am extremely grateful to my esteemed guide Prof. Dr.B.Saravanan M.D.S,Ph.D Professor, Department of Oral and Maxillofacial Surgery, Tamilnadu Govt. Dental college and hospital, for his filial attitude, valuable guidance, encouragement, lending me his precious time and never ending patience with out which this study would not have been possible and also for constant inspiration through out my post graduation period.

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Narrow border of language could never express my respect and gratitude to all the patients who co-operated with me for this study.

I dedicate this study to my father A.R.Thirunavukkarasu, My mother R.C. Dhanamani, my Grandmother, Brother, Cousins and Friends for their unconditional love and concern.

Last but not the least I would like to seek the blessings of the Almighty without whose grace this endeavour wouldn’t have been possible.

INSTITUTIONAL ETHICAL COMMITTEE

Tamil Nadu Government Dental College and Hospital, Chennai-3

Telephone No: 044 2534 0343
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R.C.No. 0430/DE/2010

Date: **27-03-2012**

Title of the Work	" Sternoclavicular Graft for Reconstruction of Temporomandibular Joint in Unilateral TMJ Ankylosis"
Principal Investigator:	**Dr. T. Rohini, II Year PG Student**
Department	Department of Oral & Maxillofacial Surgery

The request for an approval from the Institutional Ethical Committee (IEC) was considered for the following on the **IEC meeting held on 25-01-2012** at the Principal's Chambers, Tamil Nadu Government Dental College & Hospital, Chennai-3.

"Advise to proceed with the study"

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ABBREVIATIONS

TMJ - Temporomandibular joint

CCG - Costochondral graft

SCG - sternoclavicular graft

DO - Distraction osteogenesis

P/T - Proplast Teflon

OPG - Orthopantomograph

CT - Computed tomography

LIST OF CONTENTS

ABSTRACT:

BACKGROUND:

TMJ ankylosis is one of the most physically incapacitating and psychologically distressing conditions of the TMJ. Various treatment modalities have been proposed for treatment of TMJ ankylosis each having its own merits and demerits. The most favoured autogenous graft has long been the costochondral graft for reconstruction of ramus condyle unit but the unpredictable growth pattern of the CCG has made us to search for a better alternative. Literature revealed that the sternoclavicular joint resembled the TMJ morphologically and histologically.

AIM AND OBJECTIVES:

To evaluate the feasibility of using sternoclavicular graft for TMJ reconstruction in TMJ ankylosis and to also assess this technique in restoration of mandibular movement and function and growth of the mandible

METHODS:

Five patients with unilateral ankylosis were included in this prospective study. All patients underwent TMJ ankylosis release and reconstruction of the joint with Sternoclavicular joint.

OBSERVATION & RESULTS:

Our results revealed that there was anatomic resemblance of the sternoclavicular graft to the TMJ and there was no donor site morbidity as there was regeneration of clavicle at the donor site.The mouth opening was normal (more than 30mm) in all the cases during the follow up period after the reconstruction of the TMJ with SCG. Moreover the patients were subjectively satisfied with the outcome of the results. It is important to note that the psychological inhibition which was present before surgery is entirely alleviated

INTERPRETATION AND CONCLUSION:

Within the limitations of this study, it was concluded that Sternoclavicular Joint could be a reliable and versatile alternative for reconstruction of TMJ.

KEY WORDS: Temporomandibular joint,sternoclavicular graft,maximum incisor opening,ankylosis

Introduction

Temporomandibular joint Ankylosis is one of the most distressing clinical conditions resulting in loss of jaw function and impairment of growth. Ankylosis is the greek word meaning "Stiff Joint". It is defined as bony or fibrous adhesions between anatomical components of the Temporomandibular joint.[120]

Several factors have been attributed to the formation of TMJ ankylosis, of which the most common cause being the trauma (13-100%) to the condyle.[119] Infection also contributes to the formation of TMJ ankylosis, but has become rare after the advent of the antibiotics. The outcome of the pathogenesis of the condylar fracture depends on the period of immobilization, extent of damage to the articular disc, the age of the patient and finally the type of condylar fracture.[55,94]

Ankylosis is classified as true and false (Kazanjian1955)[48]. Any condition that gives rise to osseous or fibrous adhesions between surfaces of TMJ is a true ankylosis. Topazian believed that these two types represent variation of the same pathophysiologic process[116]. Ankylosis of TMJ may be classified as,

1. **Intra or Extra articular** (by location),
2. **Fibrous**, **Fibro-osseous, osseous** (type of tissue involved),
3. **complete, incomplete** (extent of fusion),
4. **Unilateral or Bilateral** (side of location)[119,120]

Pseudo or false ankylosis is a condition where the hypomobility of the joint is due to extra articular causes such as hyperplasia of coronoid process, untreated fractures of zygomatic arch, radiation induced fibrosis of temporalis muscle, neurological or psychological disorders (Valentine 2002, Spijkervet 1994).[112,119]

The temporomandibular ankylosis whether unilateral or bilateral will result in difficulty in mastication, yawning, speech, poor oral hygiene. Inability to open the mouth will lead to poor nutrition and interference with any dental treatment. It is also associated with airway problems and growth retardation, developmental deformities particularly in growing individuals.

The Temporomandibular joint ankylosis leads to facial asymmetry resulting in psychosocial problems in the affected patients. Unilateral ankylosis is associated with chin deviation to the affected side, vertical deficiency of the maxilla and the mandible on the side of defect, retrognathic mandible with short ramus, convex facial profile, absent or deficient cervico-mental angle, fullness of face on affected side, flatteneing on unaffected side, and prominent antigonial notch. In case of bilateral ankylosis, the patients presents with a bird face appearance in profile view.[85] .

The intra oral features includes occlusal cant with deviation of maxillary and mandibular midlines toward the affected side, class II malocclusion although class I occlusion may occasionally be seen, posterior cross bite, severe oralhygiene problems leading to caries and dental problems. In bilateral ankylosis there may be an associated open bite.[85]

The main objectives of the treatment for Temporomandibular joint ankylosis are to improve mouth opening, restore joint function, allow for mandibular growth, improve the patient's facial profile and prevent reankylosis.[85]

The etiology of recurrence of ankylosis has been postulated to be failure to have aggressive physiotherapy, poor compliance by the patient. **Kaban** postulated that recurrence could be due to inadequate excision of ankylotic mass[46]. Functionally hypomobility restricts all types of mandibular movements (protrusive, lateral, opening).

TMJ ankylosis should be treated as soon as the condition is recognized in order to minimize the restriction of facial growth. In view of the technical difficulties and high incidence of recurrence the surgical management of temopormandibular ankylosis poses a significant challenge to both the surgeons and the patients. The various techniques for surgical correction of TMJ ankylosis are Gap arthroplasty, Interpositional arthroplasty, and Joint reconstruction[2]. Numerous materials have been suggested for reconstructing the TMJ including autogenic, alloplastic and xenogenic bovine bone grafts.

The autologous bone grafts used to reconstruct the TM joint includes costochondral grafts and sterno clavicular bone grafts. Traditionally, the costochondral grafts have been used for reconstruction of TM Joint in ankylosis patients, but because of the unpredictable growth, warpage, and fracture of the costochondral grafts have created a background for dissatisfaction and prompted a search for an alternative (Singh *et.al* 2011)[107] .

It is observed that in humans the sterno clavicular joint and Temporo mandibular joint are similar anatomically and physiologically.[12] This similariy of the joints have encouraged the surgeons to use SCG as an alternative to costochondral

grafts. The good functional outcome reported in the literature using SCG as interpositional material supports its usage.

The purpose of this dissertation is to assess the versatility of sternoclavicular graft as an interpositional material in the reconstruction of Temporomandibular joint ankylosis patients reported to the Department of Oral & Maxillofacial surgery, Tamilnadu Government Dental College & Hospital, Chennai.

Aim and objectives

AIM AND OBJECTIVES

AIM:

To evaluate the feasibility of using sternoclavicular graft for TMJ reconstruction in TMJ ankylosis and to also assess this technique in restoration of mandibular movement and function and growth of the mandible

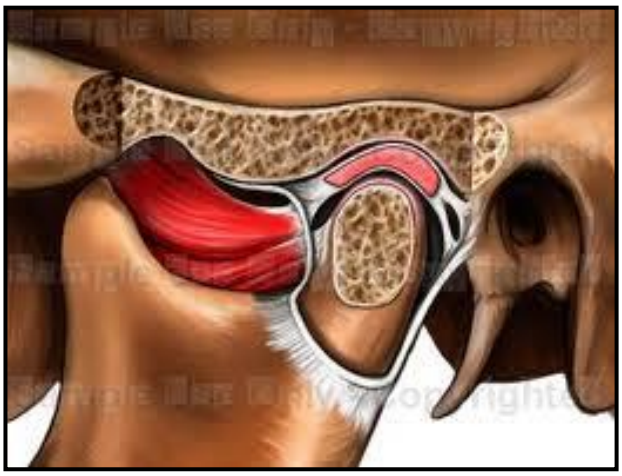
OBJECTIVES:

1. To achieve a functional & aesthetic facial harmony
2. To establish functioning articulation with an adequate range of mandibular movement.
3. To analyse the functional adaptation of the graft.
4. To evaluate the clinical stability.
5. To assess the amount of growth achieved
6. To evaluate intraoperative risk factors and its after effects on clinical and functional recovery.

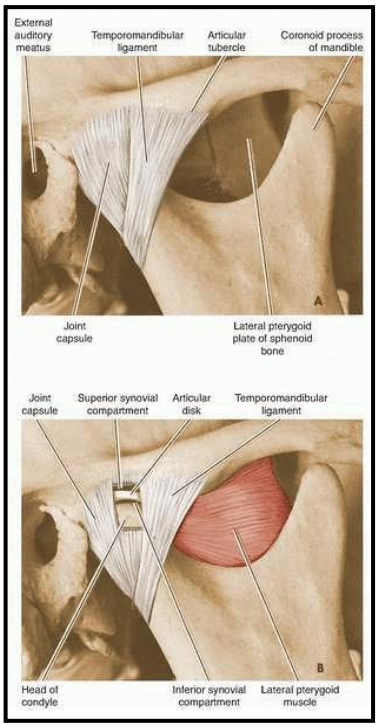
Surgical Anatomy

SURGICAL ANATOMY

Applied Surgical Anatomy:



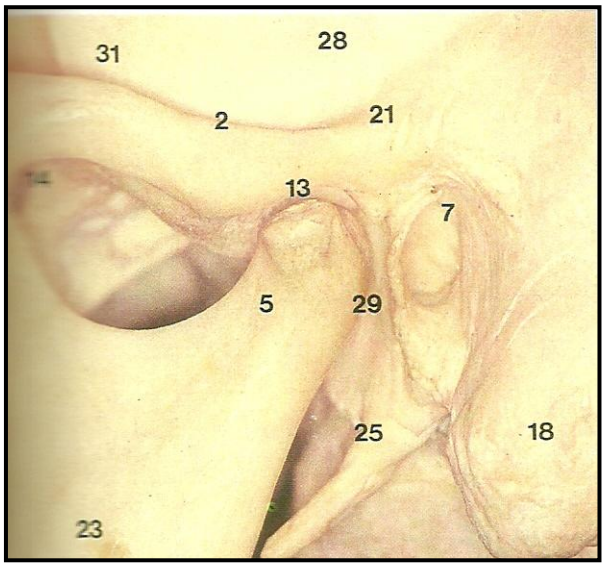
Temporomandibular joint is a ginglimo diarthroidal joint and is unique from all other joints in our body. First, it is the only joint in the body whose movements are limited not only by the shape of the bones, ligaments, adjacent soft tissues and muscle activity but also by the occlusion of the teeth through their connection to the articulating bones. Second the left and right joints are connected by a single bone, the mandible



Cranial Component

The articulating surfaces are not covered by hyaline cartilage but by fibrous cartilage in which respect it is similar to the sternoclavicular joint. The condylar cartilage provides the development sufficient to maintain the condyle in its location in the glenoid fossa, whereas the growth of the mandible depends on the concept of "Functional Matrix" (Moss and Rankow 1968) ie., the mandible develops to a size determined not only genetically but also by the stimuli of the orofacial musculature in response to the increasing functional demands of the growth. [75]

Condylar Component



The condyle is roughly elliptical in shape with its mediolateral dimension varying between 13mm and 25mm and the anteroposterior width between 5.5mm and 16mm. The subarticular zone of the cartilage is not the site of active growth but rather that of secondary adaptive responses, maintaining the relationship of the condyle to the base of the skull as it expands laterally, and of remodelling changes whereby the shape of the condyle is altered in response to gradual changes in its functional environment.

The condyle is vascular at birth and vessels anastomose over the articular surface, and these disappear by the age of 3 years (Blackwood 1965). The articular surface of the condyle is covered by fibrocartilage and faces upward and forward, so that when the condyle is viewed from the lateral aspect it appears to be bent anteriorly upon its neck. The neck is thin and elongated and is readily fractured. Although it is an apparent weakness, this feature gives some protection to the delicate roof of the glenoid fossa. The upper bony element of the joint, the temporal component, is quite flat at birth. Gradually, the adult contour of the glenoid fossa is achieved primarily by apposition of the bone in the region of the articular eminence, and to some extent by bone resorption in the glenoid fossa. At the same time, in response to function, the characteristic form and flexibility of the meniscus is established by reorientation of the constituent fibres.

Glenoid Fossa

The superior aspect of the joint is formed by the concave glenoid fossa posteriorly and the convex articular eminence anteriorly. The glenoid fossa is bounded in front by the squamous part of the temporal bone and posteriorly by the non-articulating part formed by the tympanic element. The articular surface of the glenoid fossa is smooth, oval and deeply concave, articulates with the articular disk of the temporomandibular joint. The non articulating portion sometimes lodges a small part of the parotid gland. The articular surface is lined by the fibrocartilage. Above the thin bony roof lie the contents of the middle cranial fossa, viz., meninges and brain. The thinness of the plate renders it liable to damage from trauma and there are accounts of the condyle being driven upwards into the middle cranial fossa.

Articular Eminence

The articular eminence is formed by the squamous part of the temporal bone, which forms the anterior boundary of the glenoid fossa. It is strongly convex anteroposteriorly, its flat surface merges with the temporal bone and the glenoid fossa whereas laterally it is bound by the bony ridges. The articular eminence is also largely covered by fibro cartilage. Its boundaries are indistinct and it merges anteriorly into the zygomatic arch. When removing a mass of ectopic bone, it is a matter of surgical importance to avoid perforation of the middle cranial fossa. Such massive new bone formation may encroach on the medial side of the neck of the condyle which is in close relationship to the internal maxillary artery.

The Articular Disk

The first sign of articular disc development is seen as a mesenchymal condensation craniolateral to the condyle in embryos at the 8th week of development (Symons, 1952). The articular disk lies approximately in the horizontal plane and divides the joint space into upper and lower compartments. Toller (1974) has estimated that the upper compartment can accommodate 1.2ml and lower compartment 0.9ml of fluid without undue pressure being created. Hansson et al (1977) reported that the middle and posterior parts of the disk are thicker mediocentrally than laterally in adults but not in children. The disk is pliable, since if it is unyielding it cannot stabilize the condyle against the articular eminence during translation. It can alter its shape as condyle moves forward and backward from the glenoid fossa on to the articular eminence, adapting to variations in the shape of the condyle.

At birth the disk is vascular but the central region later becomes avascular. Posteriorly, it contains two layers of fibres with loose connective tissue separating them, this is the bilaminar zone. The upper layer is composed of elastin and the lower is collagenous with blood vessels and nerves mainly in the superior part of the bilaminar zone, a situation which complements the relative movements between the disc and the upper and lower compartments.

The Fibrous Capsule

It is a fibrous sac that surrounds the entire joint area. It is attached above to the articular tubercle in front, to the lips of the squamotympanic fissure behind, and between these two attachments to the circumference of the mandibular fossa, below to

the neck of the mandible. Above the articular disk, the capsule forms a loose envelope, while below the disk it is taut. This arrangement allows the hinge and simultaneous gliding movement of the disk and condyle.

Synovial Membrane

The synovial membrane lining the capsule covers all the intra articular surfaces, upper and lower cavities except the pressure bearing fibrocartilage. Thus the synovial membrane is continuous with the fibrous tissue covering the disc and the surface of the condyle and the temporal articulation. The synovial villi increase the flexibility of the inner surfaces of the capsule enabling the changes in the shape of the disk and sulci to occur during the normal movements. The villi may also have the effect of promoting the distribution of the synovial fluid over the articulating surfaces. Its major functions are apparently to produce the fluid, lubricating the joint and to repair the wear, and drain the debris accumulating from normal function.

The Articular Ligaments

The articular capsule is strongly reinforced laterally by the temporomandibular or lateral ligament. It runs obliquely downwards and backwards being attached above to the articular tubercle on the root of the zygoma and below to the lateral surface and posterior border of the neck of condyle. “Burch” indicated that the temporomandibular ligament and capsule remain taut during all ranges of mandibular motion. The stylomandibular and spheno-mandibular ligaments however slacken and fold during opening and thus fail to support the mandible during opening.

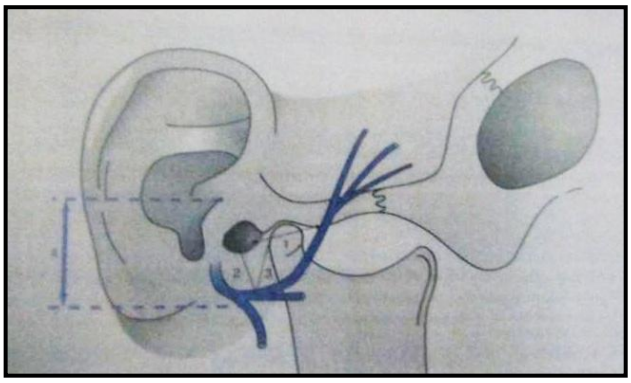
Blood Supply

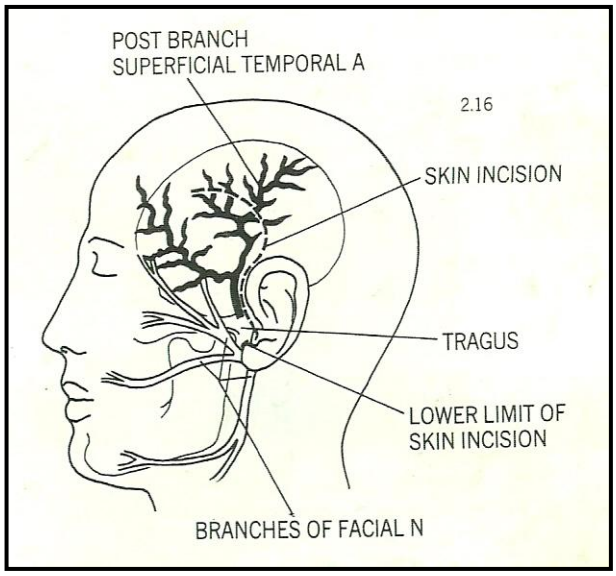
The major blood supply of the joint proper is derived from the superficial temporal, middle meningeal, anterior tympanic and ascending pharyngeal arteries whilst the glenoid fossa is supplied by the deep auricular branch of the maxillary artery. Majority of these vessels enter the posterior aspect of the joint and if this area is involved in a surgical incision, profuse bleeding may be encountered. However the meniscus, the fibrous and fibrocartilage layers are mainly avascular and depend for their metabolism on diffusion from the deeper bone and superficially, the synovial fluid.

Nerve Supply

The nerve supply of the joint consists of a dense plexus of unmyelinated fibres that weaves throughout the fibrous capsule. The small diameter afferent pain fibres are derived from branches of the auriculotemporal nerve and from the masseteric branches of the mandibular division of the trigeminal nerve (Sicher1970). These small branches intercommunicate and this accounts for wide area of pain emanating from the joint. There are no nerve endings of any type in the fibrous articular surface, the fibrocartilage, disk or synovial membrane. These structures therefore are certainly not the cause of primary pain, which is probably produced only by the mechanical or chemical irritation of the sensitive capsular tissues surrounding the joint.[32]

Related Anatomy Of The Operated Area:





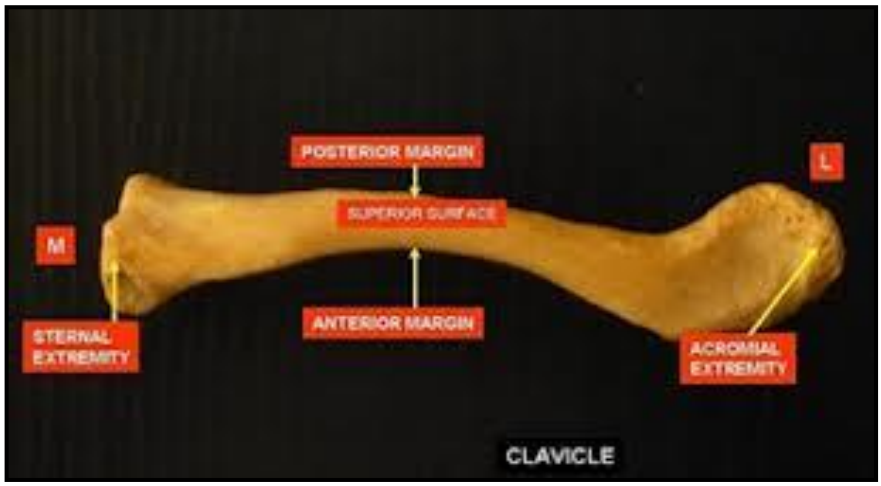
The facial nerve, auriculotemporal nerve, the superficial temporal artery, the maxillary artery, the transverse facial artery are intimately involved in the surgical dissection of the temporomandibular joint. Care should be taken to avoid injury to these structures.

The anatomic relationship of the facial nerve to the zygomatic arch and the margins of the bony external auditory canal have been studied by Alkayat and Bramley (1979). The point of bifurcation of the facial nerve into the temporofacial and cervicofacial divisions lies within 1.5 to 2.5 cm below the lower concavity of the bony external auditory canal, and in the inferoposterior direction from the lower point

of the posterior glenoid tubercle, the distance ranges from 2.4 to 3.5 cm. The temporofacial division and the most posterior twigs of the temporal branch as it crosses the zygomatic arch are found to be within 0.8 to 3.5 cm from the anterior concavity of the external auditory canal.[3]

Knowledge of the distances and the range of the facial nerve branches from the fixed bony landmarks within the surgical field are important in order to avoid injury to the facial nerve while approaching the temporomandibular joint. The avoidance of damage to the facial nerve and its branches at various levels of dissection during surgery also depends on a precise knowledge of the plane in which it runs.

Surgical anatomy of sternoclavicular joint:



The sternoclavicular joint is a synovial joint formed by medial end of clavicle, clavicular notch of the maniburium and cartilage of the first rib. A sleeve like capsule bridges the gap between sternum and clavicle. The ligaments of the joint are:

- **Capsular:** which is thickened in front and behind but above and especially below it is little more than loose areolar tissue.
- **Anterior sternoclavicular ligament**: is broad and attached above to the anterosuperior aspect of clavicle's sternal head and passes inferomedially to the upper anterior aspect of manubrium spreading to first costal cartilage.
- **Posterior sternoclavicular ligament*:*** a weaker band posterior to the joint descends inferomedially from the back of Clavicle's sternal head to back of upper manubrium.
- **Inter Clavicular ligament***:* continuous above with deep cervical fascia unites superior aspects of sternal ends of both clavicles.

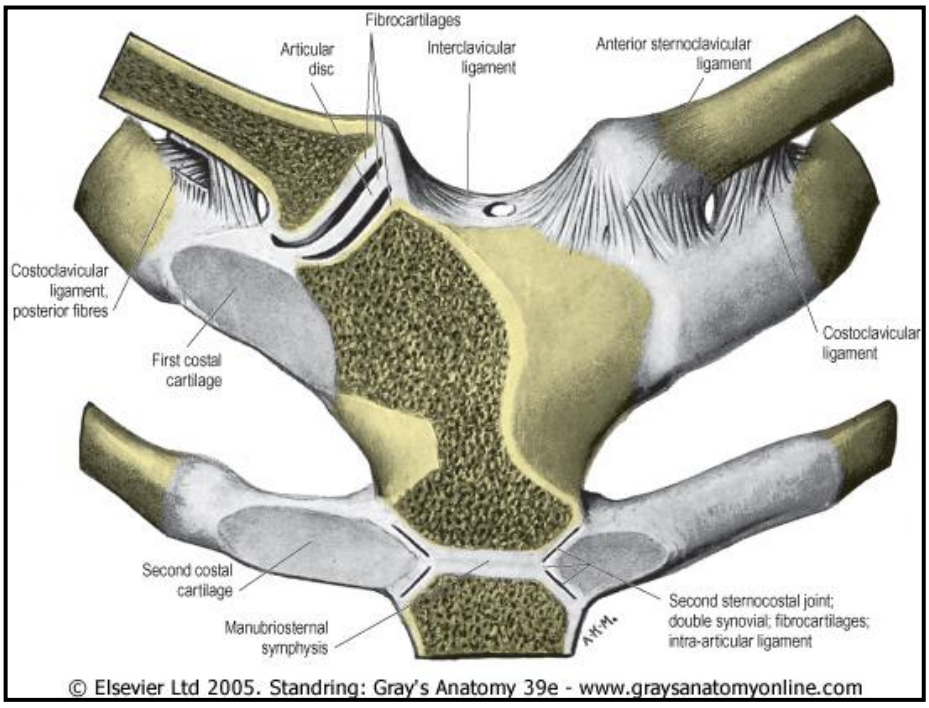
- **Costoclavicular ligament:** is like an inverted cone with anterior and posterior laminae attached to upper surface of first ribs and costal cartilage.

Lateral Ligaments:

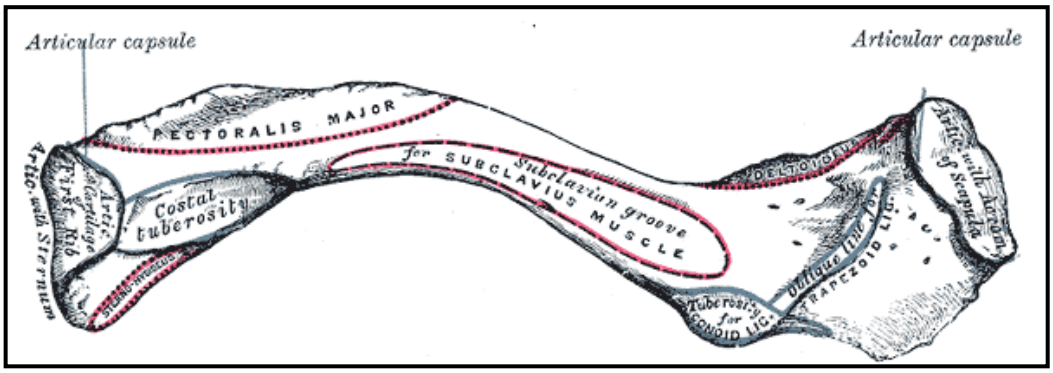
Coracoclavicular ligaments*:* trapezoid and conoid are thick, strong ligaments from the base of coracoid process of scapula to the inferior aspect of lateral clavicular ligaments.

Acromioclavicular ligament*:* The articular disc is flat and almost circular between sternal and clavicular surfaces attached above to the superioposterior border of clavicular articular surface, below to first costal cartilage near its sternal junction.

Ligaments of clavicle:

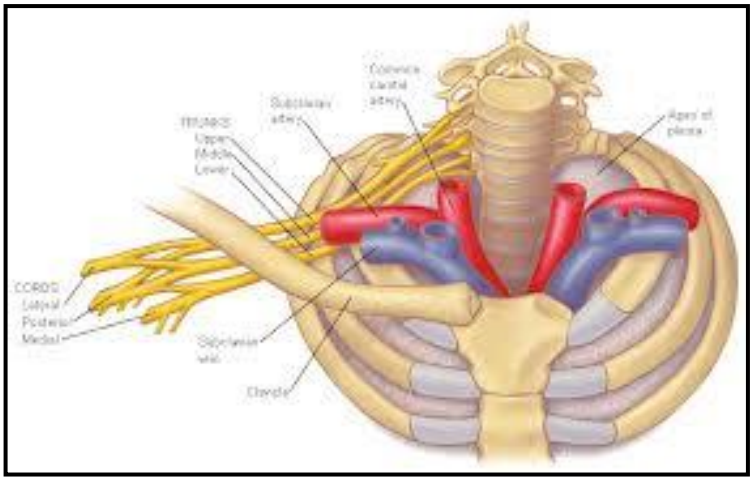


Muscular Anatomy:



Medially, the clavicle seems as an origin of pectoralis major and sternohyoid muscles, superomedially clavicle serves as an origin of sternocleidomastoid. The undersurface of the middle clavicle serves as an insertion point for the subclavius muscle. Laterally the anterior clavicle is the site of origin for anterior deltoid with postero superior clavicle serving as an accessory insertion for trapezius. Another important muscle related to the clavicle is the platysma located in subcutaneous tissue superficial to cervical fascia, originates over the deltoid and pectoralis major and crosses the superficial anterior surface of clavicle before inserting on the mandible and skin and muscles of the mouth**.** Because of its location, division of platysma is necessary for surgical approach to mid clavicle.

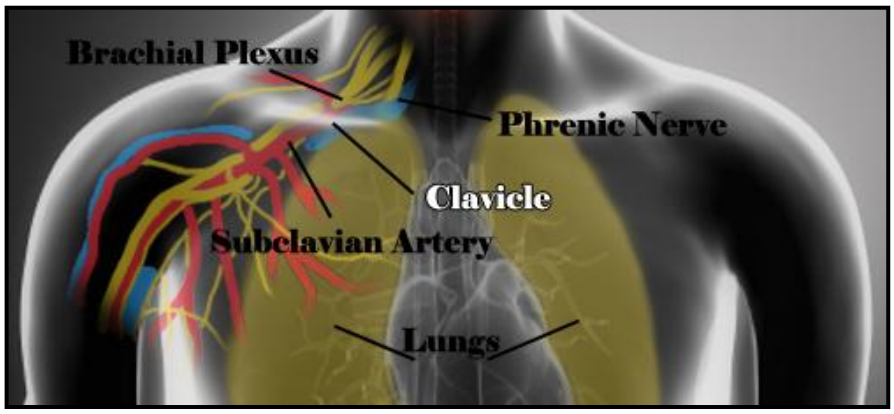
Neurovascular Anatomy:



From a surgical stand point, the important neurovascular relationship to the clavicle can be divided into anterior and posterior. Anteriorly, the main structures are supraclavicular nerves, branches of cervical plexus, these nerves originate as a common trunk at the level of posterior border of sternocleidomastoid and this trunk then divides into anterior, middle and posterior nerves that cross the superficial surface of the clavicle deep to the platysma**.** Jupiter and Ring have recommended locating and presenting these nerves during surgical approach to mid clavicle.

The clavicle has an important function as an osseous protection of the brachial, jugular and subclavian vessels. The superior surface of the middle third of clavicle forms the inferior border of the posterior triangle of the neck. The important contents of that triangle are brachial plexus, and subclavian artery.

PLEURA:



The apex of pleura extends about 3cm above the medial third of clavicle and the pleura passes downwards and medially behind the sternoclavicular joint to meet the opposite pleura behind the sternum at level of the sternal angle of Louis.[32]

Review Of Literature

REVIEW OF LITERATURE

History:

John Howship (1816)[41] gave a vivid report of the natural history of suppurative arthritis of jaw leading to ankylosis

Esmarch (1854)[2] was the first surgeon to perform on osteotomy for treating mandibular ankylosis.

Humphrey (1854)[2] performed the first condylectomy for TMJ ankylosis

Verneuil (1860)[121] was the first to use autogenous tissue for arthroplasty

Abbe et al (1880)[3] introduced gap arthroplasty

Classification:

Kazanjian(1938)[48] was the first to classify TMJ ankylosis as true or false

Topazian (1964, 1966)[116] proposed 3 stage classification of complete ankylosis, Stage-I: Ankylotic bone limited to condylar process, Stage II: Ankylotic bone extending to sigmoid notch, Stage III: Ankylotic bone extending to coronoid.

Sawhney (1985)[103] classified ankylosis based on the degree of ankylotic mass

PROTOCOL FOR TREATMENT OF TMJ ANKYLOSIS:

Kaban (1990)[47] put forth a protocol for management of TMJ ankylosis consisting of (1) aggressive resection (2) ipsilateral coronoidectomy (3) contralateral coronoidectomy if necessary (4) lining of TMJ with temporalis fascia or cartilage (5) reconstruction of ramus with costochondral graft (6) rigid fixation (7) early mobilization and aggressive physiotherapy

Didier- David *et al* (2007)[13] established a new protocol for 1 stage treatment of TMJ ankylosis using surgical navigation.

Kaban *et al* (2009)[46] introduced a 7 step protocol for management of TMJ ankylosis in children which consists of:

1) Aggressive excision of fibrous/ bony ankylotic mass
2) Coronoidectomy on the affected side.
3) Coronoidectomy on the contralateral side, if steps 1 to 2 do not result in maximal incisal opening of greater than 30mm or to the point of dislocation of unaffected TMJ.
4) Lining of TMJ with a temporalis myofascial flap or the native disc of it can be salvaged.
5) Reconstruction of Ramus Condyle unit with either CCG / DO in rigid fixation
6) Early mobilization of the jaw.
7) Aggressive physiotherapy.

Song Song Zhu *et al* (2011)[111] established a 2 stage treatment protocol for management of TMJ ankylosis with secondary deformities in adults composed of TMJ reconstruction as the initial surgery followed by orthodontic treatment and correction of secondary deformities as the second surgery, and concluded that the 2- stage treatment not only restores oral function but also improves the patients esthetic appearance.

Neelam Andrade *et al* (2012)[78] proposed new protocol to prevent recurrence of TMJ ankylosis and potentially life threatening complications in triad patients with TMJ ankylosis and obstructive sleep apnoea and micrognathia whereby distraction was done first followed by ankylosis release and distractor removal in second stage.

Incision:

Blair (1913)[5] gave operative treatment of ankylosis of the mandible.The preauricular incisions used today are modifications of Blair's curvilinear or inverted "l" incision.

Pogrel (1992)[86] advocated Bicoronal flap approach to TMJ as an excellent approach particularly in cases where bilateral operation is required

Massimo Polite *et al* (2004)[67] presented a safe surgical approach "The deep subfascial approach to the TMJ carried out by modified pre auricular incision followed by subfascial dissection.

El- Sayed *et al* (2008)[26] used a modified technique for TMJ reconstruction with CCG using an intra oral incision along the external oblique ridge to mucobuccal fold for resection of coronoid process and insertion and fixation of graft and concluded that were no visible scars, no damage to facial nerve or marginal mandibular nerve and shorter operating time.

Ko *et al* (2009)[51] evaluated the technique of intra oral approach for arthroplasty for correction of TMJ ankylosis in 14 patients and concluded that the advantages of the intraoral approach are excellent cosmetic appearance with no facial scar, lower risk of injury to the facial nerve or auriculotemporal nerve and no salivary fistula formation.

STUDIES ON INTERPOSITIONAL MATERIALS USED FOR INTERPOSITIONAL ARTHROPLASTY:

Risdon (1934)[96] introduced interpositional arthroplasty.

Franch- Ebois (1961)[28] used a strip of deepithelialized skin obtained from full thickness graft to cover mandibular stump.

Gorgiade & Altany (1967)[31] used skin grafts for TMJ ankylosis

Tucker *et al* (1990)[118] found that by using interpositional auricular cartilage in monkeys after discectomy and high condylar shave, the cartilage survived and degenerative changes of the joint were less than those on the control side in which disk was removed and no interpositional graft placed.

Paterson *et al* (1992)[81] published a case report on a patient with bilateral TMJ ankylosis secondary to psoriatic arthritis treated by interpositional arthroplasty using fascia lata.

Chossegros *et al* (1997)[9] conducted a retrospective study of their experience to compare different inter positional materials (Skin, temporal muscle, homologous cartilage) used for inter positional arthroplasty over a period of 22 years. They

observed good results in 92% of cases using total full thickness skin graft and 83% of cases using temporal muscle and homologous cartilage gave poor results.

Chossegros *et al* (1999)[10]conducted a study on full thickness skin graft interposition after TMJ ankylosis surgery and advocated that full thickness skin graft raised from retroauricular region appeared to be an effective technique for maintaining newly created joint space and 90% stability in their case series.

Zhou Li *et al* (2002)[130] conducted a study on 7 patients to evaluate the use of autogenous auricular cartilage as an interposition material after arthroplasty of TMJ ankylosis and concluded that auricular cartilage is an ideal method for the prevention of relapse as it prevented fibrosis and ossification.

G.Dimtroulis *et al* (2004)[16] did a retrospective clinical study to present the clinical experience of using dermis- fat graft as interpositional material in 11 patients followed-up for minimum of 2 years and reported recurrence of ankylosis out of 13 joints operated and found that dermis fat is an effective procedure for prevention of recurrence of ankylosis, and proposed that fat grafts alone are easily fragmented, but when attached to dermis, the fat tends to be more stable and less liable to fragment when handled and manipulated into a cavity such as gap arthroplasty.

Xing-Long *et al* (2005)[127] proposed a new method where, after separating bony fusion between condyle or glenoid fossa, the remains of the disk were mobilized over the condylar stump and sutured with articular capsule and the surface of

condylar stump and glenoid fossa was shaved which was performed in 21 cases. No recurrence occurred in patients in whom the TMJ disc was retained during operation.

Zhu *et al* (2006)[131] in a study on goats showed that the histological characteristics of the neocondyle were similar to the normal one with fibrous connective tissue covering the head of the neocondyle and thus it may play the role of articular disk and act as shock absorber.

Cheung and Lo (2007)[7] have suggested leaving a small gap between the distracted bone and glenoid fossa during activation to allow space and time for connective tissue to mature into false fibrous disk thereby avoiding any risk of recurrence of ankylosis.

Dimtroulis *et al* (2008)[14] studied fate of dermis fat grafts in human TMJ using MRI and concluded that fat was present in similar quantities within or surrounding all joints regardless of the time lapse since surgery. Intermittent compressive forces of the joint may act as a negative influence on the growth and maintenance of fat tissue within the joint space itself

Louis. G. Mercuri *et al* (2008)[72] reviewed the outcomes of total alloplastic replacement with periarticular autogenous fat graft harvested from the abdomen and grafted around the articulating portion of their prosthesis and concluded that it was a safe and effective management for recurrent ankylosis of TMJ.

Mehrotra *et al* (2008)[71] did a random control trial of dermis-fat graft and interposition of temporalis fascia in management of TMJ ankylosis in children and concluded that the use of dermis fat grafts had minimal donor site morbidity, and was a safe and effective interpositional material to prevent recurrence of TMJ ankylosis.

Anil K.Danda *et al* (2009)[2] did a comparative study on gap arthroplasty with and without a temporalis muscle flap for the treatment of ankylosis in 16 patients and concluded that there was no significant difference between the patients treated with interpositional arthroplasty and gap arthroplasy and the overall outcome depended on patient co-operation, active physiotherapy and a regular follow- up.

Dimitroulis *et al* (2011)[15] did a critical review of interpositional grafts following TMJ discectomy with an overview of dermis fat graft and various other materials. Dermis fat leaves a visible abdominal scar in spite of a good handling properties and tissue engineered articular disk are at embryonic phase of development and concluded that there is still no ideal interpositional material that satisfies all the criteria for replacement of missing articular disk.

Bipin Ashok *et al* (2011)[6]evaluated the use of temporalis fascia as an interpositional arthroplasty in TMJ ankylosis in 8 cases and found the following advantages: it is harvested at the same surgical site, zygomatic arch osteotomy is prevented, hollowing in the temporal region is not evident, damage to the temporal branch of facial nerve is avoided with careful dissection, minimal blood

loss and indicated that the temporalis fascia survives when it is carefully dissected to preserve blood supply.

Dongmei *et al* (2011)[21] did a retrospective study on surgical treatment of traumatic TMJ ankylosis with medially displaced residual condyle patients in which medially displaced condylar segment and disc was maintained to avoid joint reconstruction and only lateral arthroplasty was performed and or either masseter muscle flap (MMF) or temporalis myofascial flap (TMF) was used as interpositional material to fill the lateral space and concluded that LAP can preserve residual TMJ structures and TMF is a reliable interpositional material in LAP for prevention of recurrence of ankylosis

STUDIES ON VASCULARISED AND NON-VASCULARISED AUTOGENOUS GRAFTS FOR TMJ RECONSTRUCTION:

Bardenheur (1907)[56] reported metatarsophalangeal joint as a graft for condylar replacement using half joint transplant of the fourth metatarsal using metatarsal head for replacement of mandibular condyle.

Sir Harold Gilles (1920)[30] first described the autogenous condylar reconstruction with costochondral graft.

Smith and Robinson (1946)[108]used used iliac bone grafts in recurrent cases of bilateral TMJ dislocation in a patient who had previously undergone condylectomy for the same problem.

Dingman *et al* (1971)[18] reported the use of metatarsal as a non-vascularized free bone graft for bilateral reconstruction of TMJ.

Muliken *et al* (1982)[76] showed that highest growth rate occurs about 2 years after the placement of graft based on radiograph measurements, and followed a slow and irregular pattern, not a linear pattern.

Ting *et al* (1985)[115] described the use of free vascularized second metatarsal for reconstruction of TMJ in four cases of ankylosis and found that the intact epiphysis in the transplanted MTP joint, which contains an epiphyesal growth plate ensured normal growth of the transplant in young patient.

Kummoona *et al* (1986)[53]suggested that the cartilaginous rim of the iliac crest be grafted to the ramus of mandible with an osseous element cut from the ilium in continuity with the cap of cartilage and did not observe any creeping substitution of cartilage columns nor any cases of ankylosis although the cases were followed for only 18 months.

Loftus *et al* (1986)[60] reconstructed the condyle by superior repositioning of the pedicled stump of the proximal condylar segment into the condylar fossa as a local osseous pedicled graft based on the lateral pterygoid muscle in a case of osteochondroma.

Constantinus politis *et al* (1987)[87] studied the use of costochondral grafts in arthroplasty of TMJ and concluded that growth of the graft is possible in the

juvenile patient. Costochondral cartilage has characteristics of both primary and secondary cartilage; the secondary cartilage being responsible for harmonious growth and for adaptation into normal functioning condyle. The primary cartilage is responsive for uncontrolled and non predictable growth. If the operatively created vertical dimension is not supported by natural teeth or by a prosthetic device in the molar area, resorption of the graft may occur and sustained post operative jaw mobilization is mandatory.

Hong *et al* (1989)[39] reported the use of coronoid process for condylar reconstruction.

Markowitz *et al* (1989)[65] performed 'L' shaped osteotomy in proximal posterior border of mandibular ramus to 1 cm above the mandibular angle and the osteotomized segment is then slid upward and reshaped. In the gap between sliding segment and the mandibular angle, the ipsilateral autogenous coronoid process is inset and suggested that as a result of vertical ramus osteotomy, there is a transposition of medial pterygoid muscle to a more horizontal position which could aid in translatory movements of new condyle.

Perott *et al* (1990)[83] reported that when only 2 -4mm of cartilage were transplanted with the rib no overgrowth of the grafts occurred.

Guyuron and Lasa (1992)[35] observed the growth of costochondral graft in 4 patients, hypogrowth in one patient and normal growth in 3 patients. In addition, three cases of postoperative ankylosis were observed.

Posnick *et al* (1993)[88] first reported series of cases using the free fibula flap for immediate reconstruction of paediatric mandibular tumours.

Ko *et al* (1999)[50] reported continued growth of mandible in 7 of 10 children treated with costochondral graft. In this series the authors used graft with a 1 cm thick costal cartilage.

McIntosh (1994)[62] stated that the additional advantages of the CCG are their biological compatibility, workability, functional adaptability and the fact that they cause minimal detriment to the patient.

El-Sheikh *et al* (1997)[27] described a lefort I osteotomy that was performed concomitantly with a CCG repair from TMJ ankylosis to help in restoration of posterior facial height.

Hossein Behmia *et al* (1997)[40] conducted retrospective clinical study of 13 cases of condylar ankylosis on use of activator appliances in pediatric patients treated with CCG for TMJ ankylosis and concluded that symmetry, arch co-ordination, correction of occlusal canting, mandibular deviation, facial growth and prevention of recurrent ankylosis were obtained and better controlled only in those cases that underwent long term orthodontic activator therapy post operatively.

Ellen Wen Cling *et al* (1999)[22] evaluated postoperative growth of mandible after reconstruction of condylar process using CCG in children and found that the CCGs tend to have a vertically directed condylar growth pattern and more

laterally positioned condyle. It provides a functional condyle with growth potential, however there is a possibility of excessive growth of graft resulting in deviation of chin and mandibular prognatism.

Paul C.Salins (2000)[101] introduced new perspective in management of craniomandibular ankylosis where pseudo arthrosis is created leaving ankylotic mass undisturbed.

Rainer Schmelzeisen *et al* (2002)[93] reported on 2 cases of navigation guided resection of severe ankylosis of the mandibular condyle with a predetermined safety margin of resection toward the middle cranial fossa and proposed that navigation aided resection of ankylosis is a valuable technique in this potentially complicated procedure.

Vilkki (2002)[123]**),** in a study using whole MTP joint graft was able to observe lateral joint movement.

Saeed *et al* (2003)[98] did a retrospective study on 76 patients treated with costochondral graft in TMJ reconstruction and found that in patients with no previous surgery, arthritic disease or congenital deformity the CCG performed well but in patients with previous alloplastic disks and total joints the results were less predictable.

Guyot *et al* (2004)[34] noticed rounding off of the fibula in the glenoid fossa in patients who were followed up for 6 years.

Rahaman *et al* (2005) [92] found that tissue engineering in the mandibular condyle is not the regeneration of a single tissue but involves two integrated tissues (cartilage and bone) with dramatic distinctions in structure and function. Mesenchymal cells have been proved to have the ability to differentiate into chondrocytes and osteoblasts for tissue engineering the mandibular condyle.

Peter Donkor *et al* (2006)[84] reported an intra articular ramus ostectomy combined with CCG for treatment of recurrent ankylosis of TMJ. The technique does not require the exposure of ankylosed joint but instead creates a false and functional joint at a lower level and it also permits lengthening and advancement of the mandible.

Ahmed MM Medra *et al* (2007)[1] did a follow-up of mandibular costochondral grafts after release of ankylosis of TMJ for 7-10 years. Of the 85 grafts, they found good take remodeling in 59%, recurrence of ankylosis (9%), resorption of graft (25%), overgrowth of graft (4%), satisfactory mouth opening in 38%, unsatisfactory 18% and operation failure in 24%.

Huang *et al* (2007)[41] evaluated use of autogenous costal cartilage graft for TMJ ankylosis in adult and demonstrated that costal cartilage is a suitable material for interpositional arthroplasty.

Zeki Guzel *et al* (2007)[129] proposed a technique for TMJ reconstruction with inlay application of autogenous costochondral graft inserted into medullary cavity of mandibular ramus in 4 patients known as Cerrah Pasa's technique.

Guo *et al* (2008)[33] recommended that if an adequate length of residual fibula is left behind with careful dissection that does not disrupt the ankle syndesmosis, paediatric patients can tolerate this donor site quite well.

Potter and Dierks (2008)[91] recommended fibula as the vascularised graft of choice for defect of the mandibular condyle when the wound beds are compromised. There are other conditions that preclude the use of non vascualrized tissues.

El- Sayed *et al* (2008)[26] used a modified technique for TMJ reconstruction with CCG using an intra oral incision along the external oblique ridge to mucobuccal fold for resection of coronoid process and insertion and fixation of graft and concluded that were no visible scars, no damage to facial nerve or marginal mandibular nerve and shorter operating time.

Ya- ting Qiu *et al* (2010)[128] described a endoscopically assisted reconstruction of the mandibular condyle with a costochondral graft through a modified preauricular approach and reported that good esthetic and functional results while reducing operating time and tissue damage.

Y.Liu *et al* (2011)[57] described a method of total and partial sliding vertical osteotomy on the posterior border of the mandibular ramus for reconstruction of mandibular condyle as pedicled graft for the correction of TMJ ankylosis in 18 patients with an average follow-up period of 36 months with 2 methods wherein method I, vertical sliding osteotomy was performed on the entire posterior border

of mandibular ramus and in method II, vertical sliding osteotomy was performed on the proximal posterior border of the mandibular ramus until it was 1 cm above the angle and ipsilateral autogenous coronoid process was resected and reshaped and was implanted in the gap between the sliding segment and angle of mandibular and concluded that this method had less complications, enough blood supply as the medial pterygoid attached to the posterior border reduces resorption and relapse, has bone with adequate size and shape for reconstruction of new condylar and resolved some of the problems of secondary mandibular asymmetry.

Shan Yong Zhang *et al* (2011)[106] did a study to introduce preliminary application of rapid prototyping (RP) for TMJ reconstruction and reported that there were short comings in this technology such as no good preoperative design and reconstruction for soft tissue, and costochondral cartilage was not shown clearly on CT Scan, in spite of high surgical accuracy less operation time and minimal complications.

Sanjog. O. Chandak *et al* (2012)[102] did a computed tomographic analysis of the position of mandibular canal in unilateral TMJ ankylosis patients in which distance between external surface of buccal cortical plate and outer surface of mandibular canal (B) and the distance between the external surface of lingual cortical plate and outer surface of mandibular canal (L) and distance between the inferior border of mandible and outer surface of mandibular canal and reported that to minimize the risk of injury to the inferior alveolar nerve these measurements should be considered separately on the ankylosed and normal sides

when planning mandibular osteotomies for DO and when using monocortical screws in ankylotic patients.

Alexander *et al* (2012)[2] did a systematic review and meta analysis of operative management of TMJ ankylosis and concluded that patients who underwent gap arthroplasty had significantly better post operative maximal incisal opening than those undergoing ankylosis resection and ramus- condyle unit reconstruction with a CCG.

Mehrotra *et al* (2012)[71] conducted a study to evaluate the feasibility of using preshaped hydroxyapatite / collagen condyles as carrier for platelet rich plasma (PRP)after gap arthroplasty in patients with TMJ ankylosis and reported that PRP plasma induces osteogenesis in the osteoconductive hydroxyapatite which is incorporated into host bone more readily and collagen provides additional space for bone to form as it resorbs, makes material less brittle and can be screwed to stump of the ramus and at 18 months, showed a opaque condyle suggesting a newly formed condyle. However they proposed a long term study to follow the growth pattern and to see if the patients develop any facial deformity as they grow.

STUDIES ON ALLOPLASTIC RECONSTRUCTION OF TMJ:

Christensen *et al* (1963)[11] reported fossa implant.

Wolford *et al* (1994)[125] found that the foreign body giant cell reactions to proplast Teflon implants was proliferative and worsened in time as more particles were generated.

Orhan guven *et al* (2004)[79], in his paper, the use of a modified fossa implant composed of titanium mesh and acrylic was described.

Mercuri *et al* (2009)[73] put forth the considerations for the use of alloplastic TMJ replacement in the growing patient as:

1) High inflammatory TMJ arthritis unresponsive to other modalities of treatment.
2) Recurrent fibrosis/ bony ankylosis unresponsive to other modalities of treatment
3) Failed tissue graft (bone or soft tissue)
4) Loss of vertical mandibular height or occlusal relationship because of bony resorption, trauma, developmental abnormalities/ pathologic lesion.

Pearce *et al* (2009)[82] reported a single stage technique for replacement of ankylosed joint using a custom made prosthesis.

Westermark *et al* (2010)[124] reported on 8 years of follow-up of patients treated with Biomet total joint prosthesis for TMJ reconstruction and the outcome supports prosthetic TMJ reconstruction as a useful treatment modality in patients with advanced TMJ disease.

STUDIES ON DISTRACTION OSTEOGENESIS AND STAGED TREATMENT FOR TMJ ANKYLOSIS:

El-Sheikh *et al* (1997)[27] described a lefort I osteotomy that was performed concomitantly with a CCG repair from TMJ ankylosis to help in restoration of posterior facial height.

Stucki- McCormick (1997)[113]was was the first to apply transport DO for TMJ reconstruction in 2 cases of tumor involving the condyle. The technique involves creating a transport disc of bone from the ramus of mandible with an 'L' Shaped osteotomy whilst preserving medial periosteum and muscle attachment.

Dean and Alamillos/ Pap George or Apostolidis *et al* (1999)[80] reported on the management of TMJ ankylosis in growing patients using simultaneously DO and arthroplasty

Lopez *et al* (2004)[61] suggested that mandibular DO should be done after the arthroplasty as the growth potential of the mandible would be known only when the ankylosis had been released

Sadakah *et al* (2006)[97] conducted a study on 9 patients to evaluate the feasibility of transoral bimaxillary distraction osteogenesis before releasing TMJ ankylosis and achieved an elongation of mandible ranging from 17-25mm. Occlusal canting decreased to 0^0 in 7 patients.

Harry C.Schwartz *et al* (2008)[36] evaluated the use of transport distraction osteogenesis for TMJ reconstruction in 12 patients with a follow-up period of 7-59 months and achieved good functional level in all cases.

Louis.G.Mercuri *et al* (2008)[72] reviewed the outcomes of total alloplastic replacement with periarticular autogenous fat graft harvested from the abdomen and grafted around the articulating portion of their prosthesis and concluded that it was a safe and effective management for recurrent ankylosis of TMJ.

Cheung *et al* (2009)[7] in their comparative study of DO and CCG in animals concluded that DO is an effective reconstruction method for TMJ ankylosis matching the standards of CCG.

Song Song Zhu *et al* (2011)[111] established a 2 stage treatment protocol for management of TMJ ankylosis with secondary deformities in adults composed of TMJ reconstruction as the initial surgery followed by orthodontic treatment and correction of secondary deformities as the second surgery, and concluded that the 2- stage treatment not only restores oral function but also improves the patients esthetic appearance.

Li Wu Zheng *et al* (2011)[59] did a comparison of distraction osteogenesis vs. costochondral graft in reconstruction of TMJ condylectomy with disc preservation in 12 adult goats in which transport distraction was performed on 1 side and CCG on the other side and concluded that DO is an effective reconstruction method for

TMJ reconstruction by eliminating the need for bone grafting and its associated donor site morbidities.

Jihua Hi *et al* (2012)[45] did a staged treatment of TMJ ankylosis with micrognathia in 12 patients aged 17-27 years who underwent arthroplasty as the initial surgical procedure, followed by orthodontic treatment and correction of mandibular micrognathia by osteodistraction and advancement genioplasty as the second surgical procedure and observed an increase in average mouth opening, correction of micrognathia and remarkable cure of obstructive sleep apnoea and hypoapnea and concluded that this combined patie treatment restores not only the oral and respiratory function but also the esthetic appearance of the patient.

STUDIES ON STERNOCLAVICULAR JOINT FOR RECONSTRUCTION OF TMJ:

Hunsuck *et al* (1969)[43] performed grafts in four Rhesus monkeys using only sternal end of clavicle and in another group of four monkeys with sternal end of clavicle with its capsule and disc and after 6 months found no histologic difference between sternal end of grafts and normal condyle on the opposite side whereas the graft which consisted of the disc, there was no evidence of disc histologically.

Snyder *et al* (1971)[110] reported the first SCJ whole joint graft consisting of a portion of manubrium, the intact capsule and a portion of clavicle on 70 years old man with cylindroma and on an 8 month follow-up the patient showed good joint movement and firm mandibular union.

Snyder (1971)[109] did a study on 5 animals in which total joint replacement was performed with SCJ and a portion of the manubrium. The manubrium portion of the joint was fastened to zygomatic arch with kirschner wires and to mandibular portion with pins and after 9 months follow-up radiographic examination revealed that bone segments had not undergone resorption and remained viable and no evidence of decreased bite force , open bite and range of motion.

Reid *et al* (1978)[95]reported a free flap technique that included the clavicular head of pectoralis major muscle and overlying skin to provide a vascularized clavicular bone graft. They suggested splitting the clavicle longitudinally and repositioning it with the attached flap as entire head of clavicle was too large to fit into glenoid fossa.

Seimssen (1982)[105] described a method for TMJ reconstruction using a muscle pedicled SCG in 4 patient three with TMJ ankylosis and one with hemifacial microsomia in which a portion of clavicle attached to the SCM muscle was rotated upward to reconstruct the mandible and concluded that muscle pedicled SCG is satisfactory and acceptable,

Ellis and Carlson *et al* (1986)[24] did a study on histologic comparison of costochondral, sternoclavicular and TMJ during growth in Macaca Mulatta and found that the head of the clavicle contains layers of cartilage similar to mandibular condyle and consist of chondroblastic, prechondroblastic, hypertrophic and endochondral ossification layers at each age during growth whereas CCG does not resemble the condyle histologically and resemble the

growth plate of long bone epiphysis during growth and hence concluded that that a joint that is similar both developmentally and structurally to TMJ is sternoclavicular joint throughout the growth period.

Daniels *et al* (1987) [12]did a histologic analysis of costochondral and SCG and TMJ of juvenile monkeys and concluded that relative to growth, the sternal head of the clavicle seemed to be graft of choice and also showed that when implanted in the TMJ area SCJ graft undergoes remodeling and resembles the native condyle unlike CCG which does not.

Korula (1991)[52] described a modified technique of pedicled sternoclavicular joint transfer where a thin portion of sternal bone is included in the transport so the transferred joint is not bulky and the need to include stylohyoid as a source of blood supply is obviated resulting in easier mobilization and no necessity for division of sternal head of sternomastoid portion with pins. 9 months follow-up radiographic examination revealed that bone segments had not undergone resorption and remained viable and there was no evidence of decreased bite range of motion or open bite.

Henning *et al* (1992)[37] to investigate the long-term effects of transplanted clavicles to the temporomandibular joint (TMJ) in juvenile monkeys. Sixteen juvenile female monkeys (Macaca mulatta) were used in this experiment. Eight animals were used as controls and were allowed to grow undisturbed for an 18-month period (group control). Eight animals were divided into two groups and underwent bilateral condylar excision via extraoral vertical ramus osteotomies.

Four of these animals had their condylar segments removed and immediately replaced to serve as surgical controls (group condyle). The other four underwent condylar replacement with the sternal end of their clavicles (group SCJ). Standardized lateral cephalometric radiographs with the aid of tantalum bone markers were used to evaluate maxillary and mandibular growth. One-way analysis of variance (ANOVA) was used to determine the significance of differences between groups. All animals showed good mandibular function and a class I molar relationship following an 18-month evaluation period. Statistical analysis showed there was no significant difference in maxillary or mandibular growth between any of the three groups. The results of this investigation show that the sternal end of the clavicle may be a viable option in mandibular condylar transplant surgery.

Wolford, Cottrell (1992)[126] conducted a study that evaluated long term outcomes of 52 sternoclavicular graft for TMJ reconstruction in 38 patients and concluded that success rate in patients reconstructed with SCG with previous Proplast/ Teflon implants was 29%, in patients with inflammatory pathology the success rate was 50% and 93% in patients with non inflammatory and no P/T pathology and reported splitting the clavicle head and applying only the superior half of the clavicle for condylar reconstruction. The head of clavicle contains layers of cartilage that are similar to mandibular condyle.

Singh *et al* (2011)[107] did a retrospective analysis of 15 cases of ankylosed temporomandibular joint reconstructed with sternoclavicular joint graft (SCG), during the period 2002–2007. All cases were analyzed for functional adaptation of

the graft, considering maximum interincisal opening and protrusive and laterotrusive movement of the jaw. Significant improvement was noticed in all cases except one, although maximum improvement was seen 3–6 months postoperatively. Radiological evaluation was carried out at regular intervals for 2–3 years to assess the anatomical adaptation of the graft. No major postoperative complications were observed and all the cases showed complete regeneration of the clavicle during follow-up and concluded that reconstruction of ankylosed TMJ with sternoclavicular joint graft is a satisfactory method of treatment.

Virendra Singh *et al* (2012)[122] did a TMJ reconstruction in ankylosis with SCG and Buccal fat pad lining in 10 patients and reported that there was significant adaptation and remodeling of SCG. Buccal fat pad was used to fill the dead space, to prevent organization of hematoma, second it prevents direct contact between cut bony surfaces and hence this modality was a successful strategy in management of TMJ ankylosis.

Materials and methods

MATERIALS AND METHODS

Five patients (Four males and one female) with unilateral TMJ ankylosis, who reported to Tamil Nadu Government Dental College, were included in this prospective study. The patients were between the age group of 10-20 years.

Inclusion Criteria:

1) Unilateral TMJ ankylosis
2) Patients within age group of 10-20 years (mean age 12 years)
3) Patients presenting with no systemic contraindication for surgical procedure.
4) Patients who are motivated enough to comply with treatment regime.
5) Patients willing for regular follow-up.
6) Even cases of recurrent ankylosis.

Exclusion Criteria:

1) Patients with Bilateral TMJ ankylosis
2) Patients below 10 years and more than 20 years

Ethical approval was obtained for the study from the institutional ethical committee and informed consent obtained from each patient in the regional language (Tamil) explaining the nature of the surgical procedure and the study.

Inability to open the mouth was the chief complaint of all the patients. In all cases there was history of trauma in the chin region with three out of five patients exhibiting scar in the chin region.

Pre-operative assessment of the patients included thorough history and clinical examination, photographs in frontal, profile, submental view and intra oral photographs. Assessment of clinical parameters included maximal incisor opening, lateral excursion and protrusive movements and if possible, deviation of midline.

Radiographic analysis included Orthopantomogram, PA view of chest. CT Scans was taken in all the three planes (axial, coronal, sagittal) and 3D reconstruction to assess the mediolateral extension of ankylotic mass. PA view of the chest was taken to assess clavicular thickness and to rule out any evidence of previous clavicular fracture or pathology.

PA cephalogram and lateral cephalogram were taken to assess the facial deformity, and also to assess the significant difference in mandibular length after reconstructing the TMJ on the affected side. The difference in length between two mandibular rami was measured by dropping a perpendicular from mastoidale to bigonial line in PA cephalogram and in lateral cephalogram, condylar - gonion and condylar- pogonion lengths were measured.

In all the five patients, the following treatment protocol was carried out.

1. Release of ankylosed mass along with ipsilateral coronoidectomy on the affected side,
2. Interpositional arthroplasty with temporalis myofascial flap,
3. Reconstruction of TMJ with split Sternoclavicular Graft was done.
4. If the mouth opening was less than 30mm then contralateral coronoidectomy was also considered.

The patients were assessed post operatively for wound infection, donor site morbidity, evidence of neurological deficit in both donor and recipient site, maximal mouth opening, lateral and protrusive movements. The uptake of the sternoclavicular graft, growth of the ramus and the body of the mandible on the affected side were assessed postoperatively with radiographs.

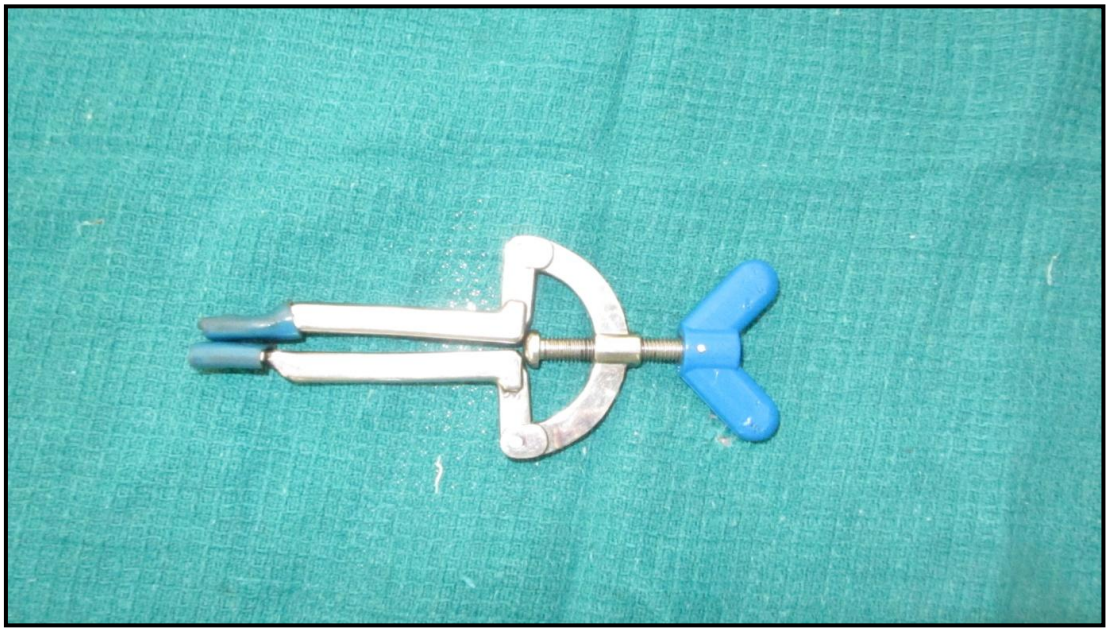
ARMAMENTARIUM

RECIPIENT

DONOR SITE

:

HEISTER JAW OPENER



SURGICAL PROCEDURE

Surgical Procedure:

The surgical management of all the cases of TMJ ankylosis were done under general anaesthesia with fibre optic assisted nasoendotracheal intubation (in four patients) and video laryngoscopy assisted orotracheal intubation in one patient.

Step-1:Intubation:

After intubation, patients were kept in supine position with head tilted laterally towards the opposite side. The ear and preauricular area was prepared using Povidone iodine (Betadine) surgical scrub and draped with sterile drapes. The external ear was lightly packed with Vaseline gauze to prevent the entry of blood and subsequent coagulation on the tympanum.

Step-2: Marking the incision:

Alkayat-Bramley incision was used to gain access to the temporomandibular joint in all our cases. The incision line was mapped out with marking ink (Toluidine blue). The incision started just within hairline, about a pinna length above the ear, and curved backwards and downwards well behind the main branches of temporal vessels to the uppermost skin attachment of pinna, following this anteriorly to the tragus and then moving vertically downwards all along the skin crease in front of the lobe of the ear.

Step -3. Infiltration of vasoconstrictor:

A Vasoconstrictor (Adreraline) with saline in a concentration of 1 in 5,00,000 injected subcutaneously in the area of incision to minimise bleeding during the surgical procedure.

Step-4: Skin incision:

Using a 15-size blade, skin incision was made through the skin and subconnective tissues (including the temporoparietal fascia) to the depth of the temporalis fascia. The bleeding vessels at this level were cauterized before proceeding for deeper dissection.

Step-5: Dissection to the TMJ capsule:

Blunt dissection was carried out in this plane and the flap was reflected anteriorly using the periosteal elevator. Working close to the cartilaginous canal automatically defined avascular plane between it and the glenoid lobe of parotid, which was turned downwards and forwards. This dissection led directly to the post glenoid tubercle and was at the same depth as the temporalis fascia reached in the upper part of the flap development.

The pocket between the lateral and medial layers of the temporalis fascia was now identified. Starting at the root of the zygomatic arch, an incision running at 45° upwards and forwards was made through the superficial layer of temporal fascia. The zygomatic arch was exposed after reflecting the periosteum, lateral layer of temporal fascia and superficial fascia as one layer. Downward dissection exposed the capsule.

Step-6: Exposing the ankylotic mass:

Inverted "L" shaped incision was made in the capsule. Subperiosteal dissection was carried out antero-inferiorly to expose the ankylotic mass.

Step -7: Gap arthroplasy:

The ankylosed segment was removed using upper and lower osteotomy cuts and a gap of about 1.5 cm was created. Adequate mouth opening in the range of 30 to 35mm was achieved. In cases where coronoid hypertrophy was observed, ipsilateral coronoidectomy was done.

Step-8 Procurement of sternoclavicular graft:-

The donor site was painted and draped. An infraclavicular transverse incision was made from the condylar head of sternoclavicular joint, to about 2-3cm laterally.The incision was Carried sharply through the subcutaneous tissue and platysma, leaving the skin flaps thick. The supraclavicular nerves not dissected as there are no evidence of any detrimental effects from cutting these nerves, and because wound dehiscence is a fear, concerns about potentially thinning soft-tissue flaps to search for them have made dissection of supraclavicular nerves unnecessary. The overlying fascia and periosteum are next divided, in line with the clavicle. This step is performed sharply and down to bone, again leaving thick flaps for later closure. The division is started medial and lateral to the proposed osteotomy site and then proceeds to the site.The osseous ends are freed from surrounding tissues. Soft-tissue is circumferentially removed only from the osseous ends. Muscle attachment and periosteum was dissected from superior and medial aspects of clavicle, maintaining the integrity of

ligamentous attachment of articular disc to clavicular head. In all cases a split thickness graft was used leaving the inferior part intact. The articulating end of the graft was shaped to simulate head of condyle anatomically.

The recipient bed was prepared to receive the graft by decorticating the lateral aspect of ramus and the graft was fixed on lateral aspect of ramus using 1.5x10cm screws through submandibular incision.

Step 8: Interpositioning of temporalis fascia & closure:

The temporalis muscle and the fascial flap was raised using the cutting diathermy to the desired length up to the junction of the zygomatic arch. The temporalis myofascial flap was mobilized and interposed between the sternoclavicular graft and the glenoid fossa. The incisions were closed layer wise using 3-0 vicryl and 3-0 prolene by simple interrupted sutures.

Postoperative phase:-

All patients were extubated and recovery was uneventful. Postoperatively all the patients were administered appropriate antibiotic and analgesics for 5 days. Sutures were removed on the 10^{th} day and all patients were placed in inter maxillary fixation (IMF) for one week for stabilization of the graft and post operative physiotherapy was commenced on the 7^{th} day. After IMF release "Heister jaw opener" was used for 6 months to maintain and improve the intra-operative mouth opening. The patients were advised arm sling for one month to minimize chances of clavicular fracture, and were instructed not to lift anything heavy or ride bicycle for 3 months or use the arm to lift themselves out of the bed. Regular follow-up was carried out weekly for first one month and once in two weeks for 3 months and once in a month for next 2 months.

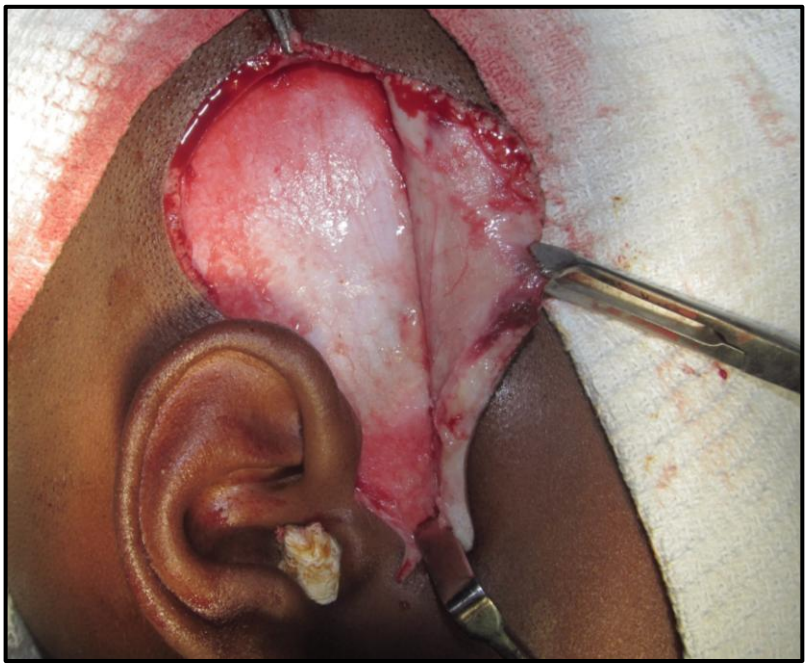
SURGICAL TECHNIQUE

STAGE I: GAP ARTHROPLASTY AND INTERPOSITIONING OF TEMPORALIS FASCIA

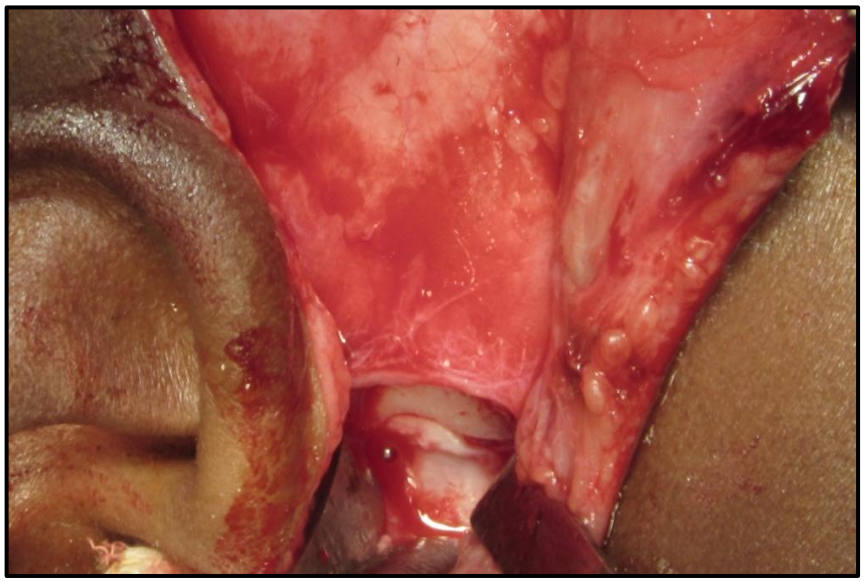
MARKING OF THE INCISION

INCISION

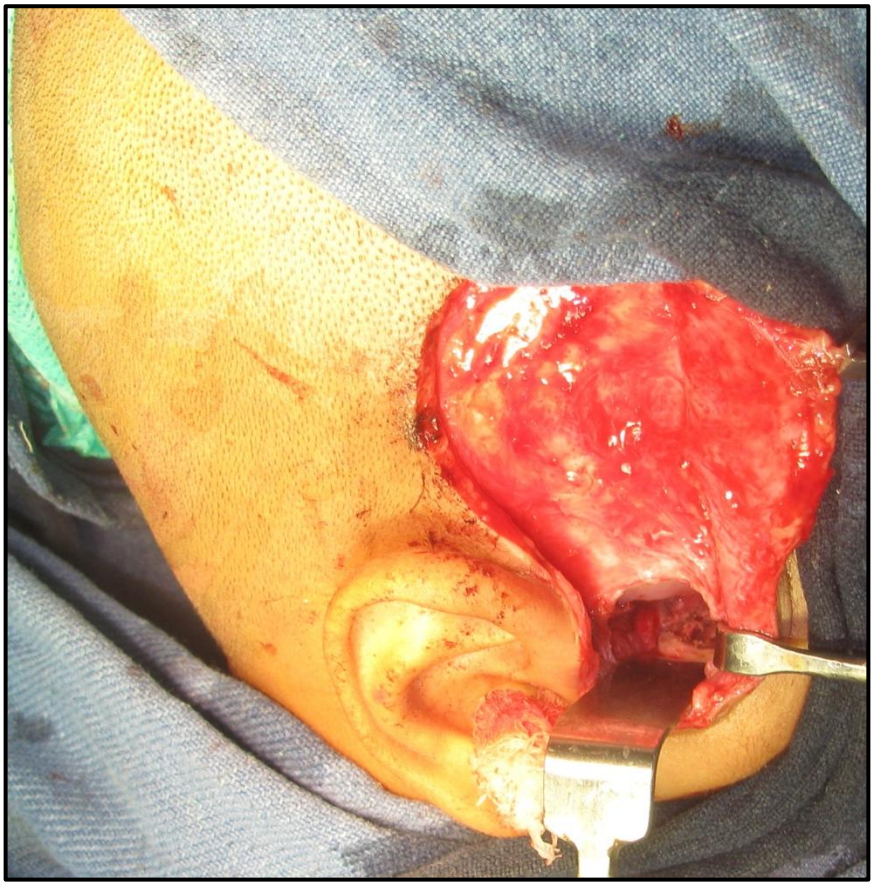
EXPOSURE OF TEMPORALIS FASCIA



EXPOSURE OF ANKYLOTIC MASS

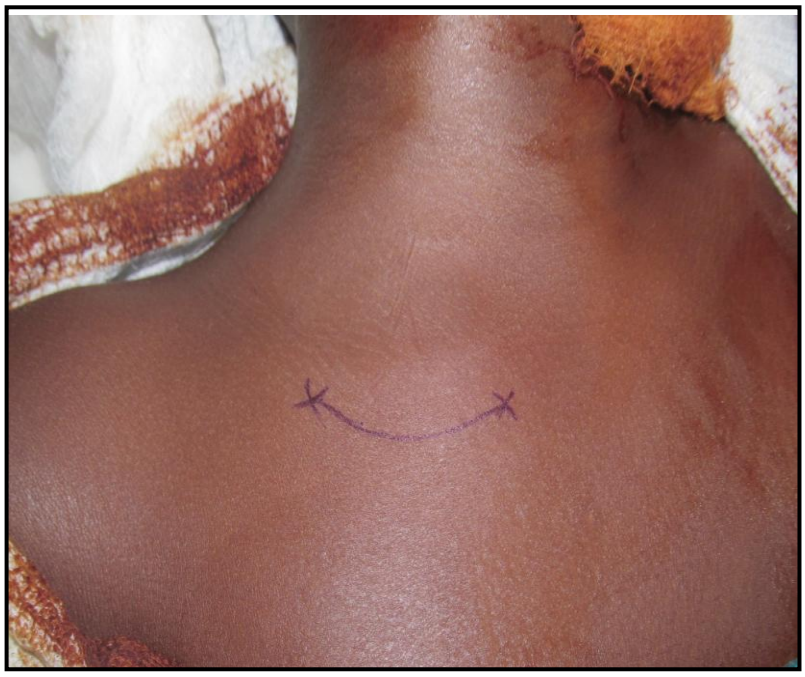


GAP ARTHROPLASTY



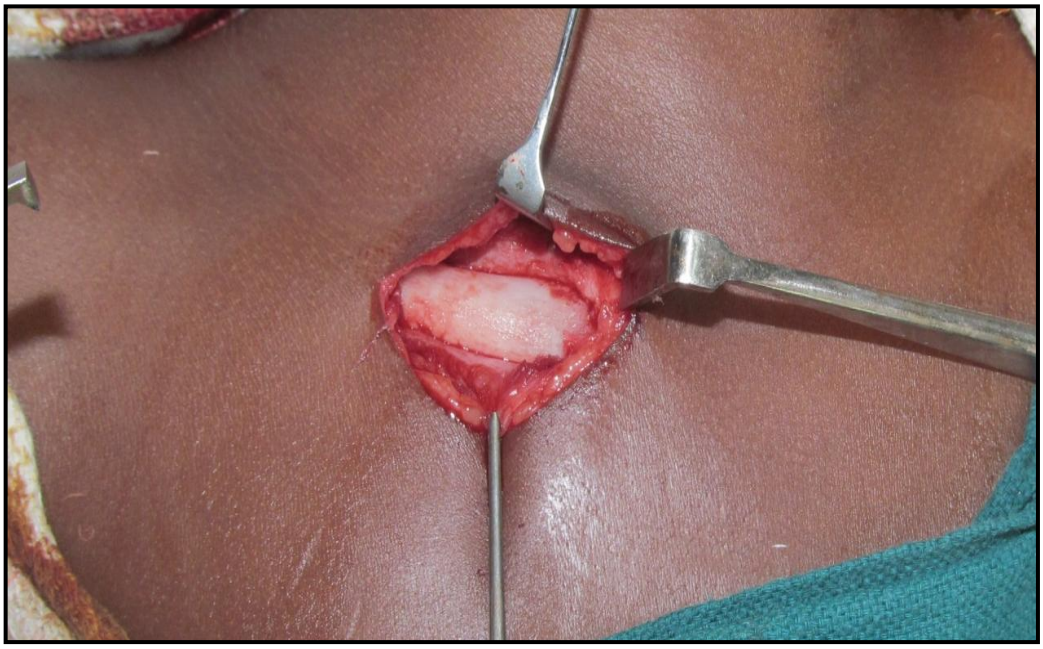
STAGE II - PROCUREMENT OF THE GRAFT:

MARKING INFRACLAVICULAR INCISION:

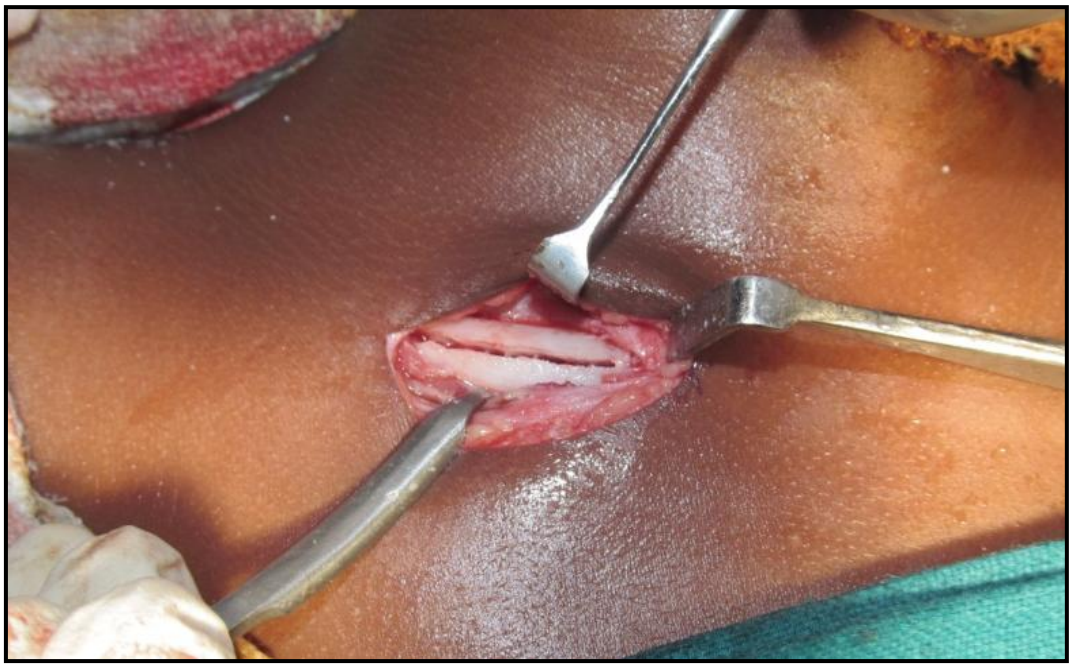


INCISION

EXPOSURE OF CLAVICLE

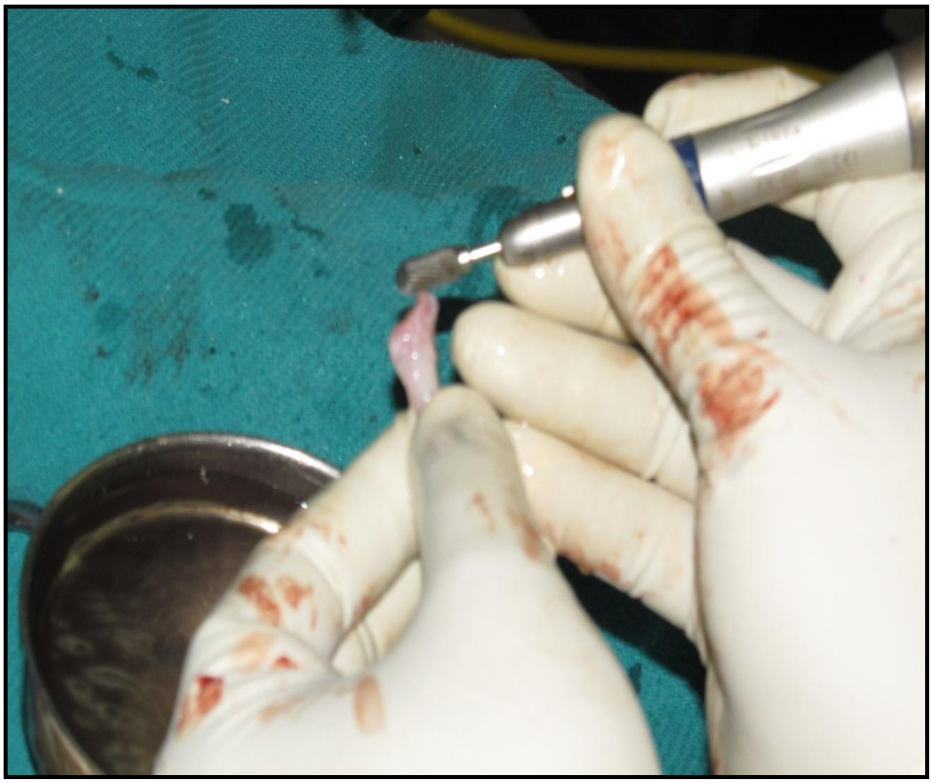


OSTEOTOMY CUT FOR HARVESTING OF GRAFT

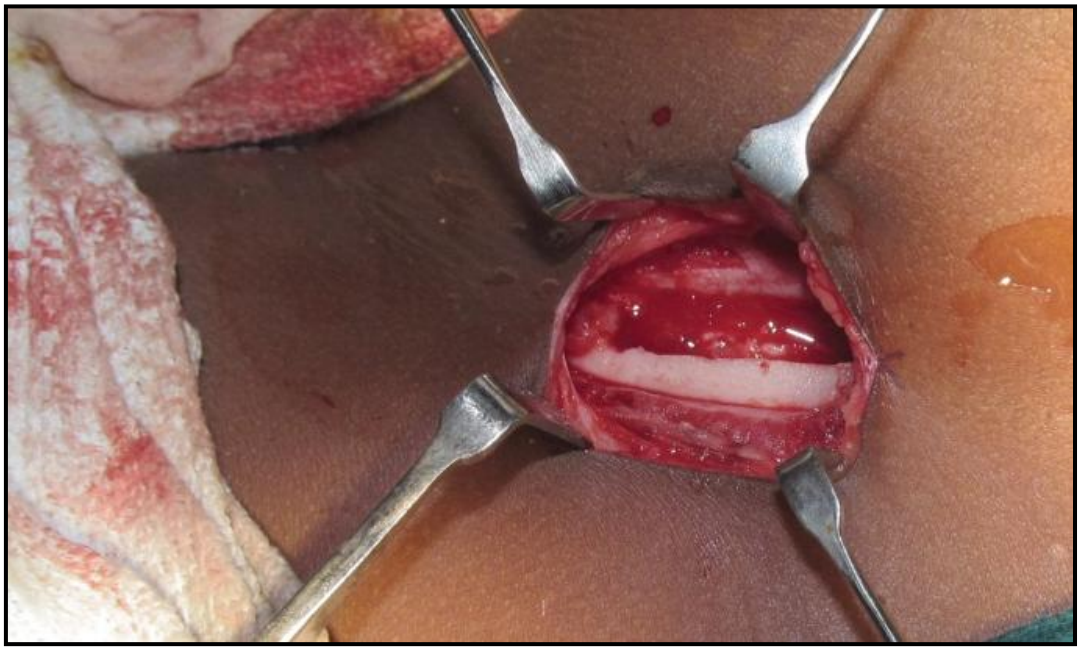


HARVESTED STERNOCLAVICULAR GRAFT

SHAPING OF GRAFT



DONOR SITE AFTER HARVESTING OF SPLIT THICKNESS GRAFT



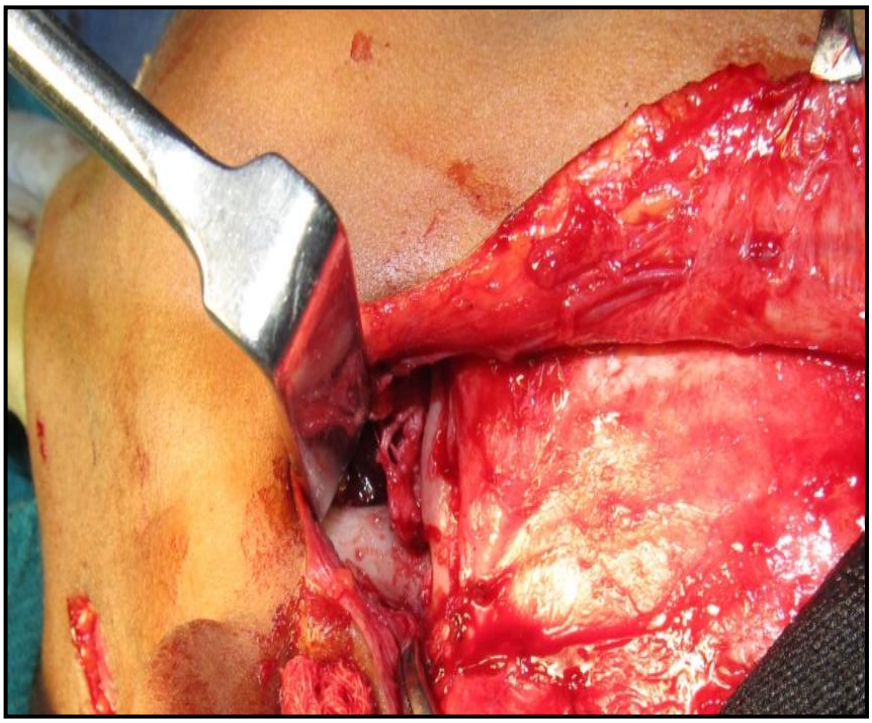
WOUND CLOSURE

STAGE III: FIXATION OF GRAFT

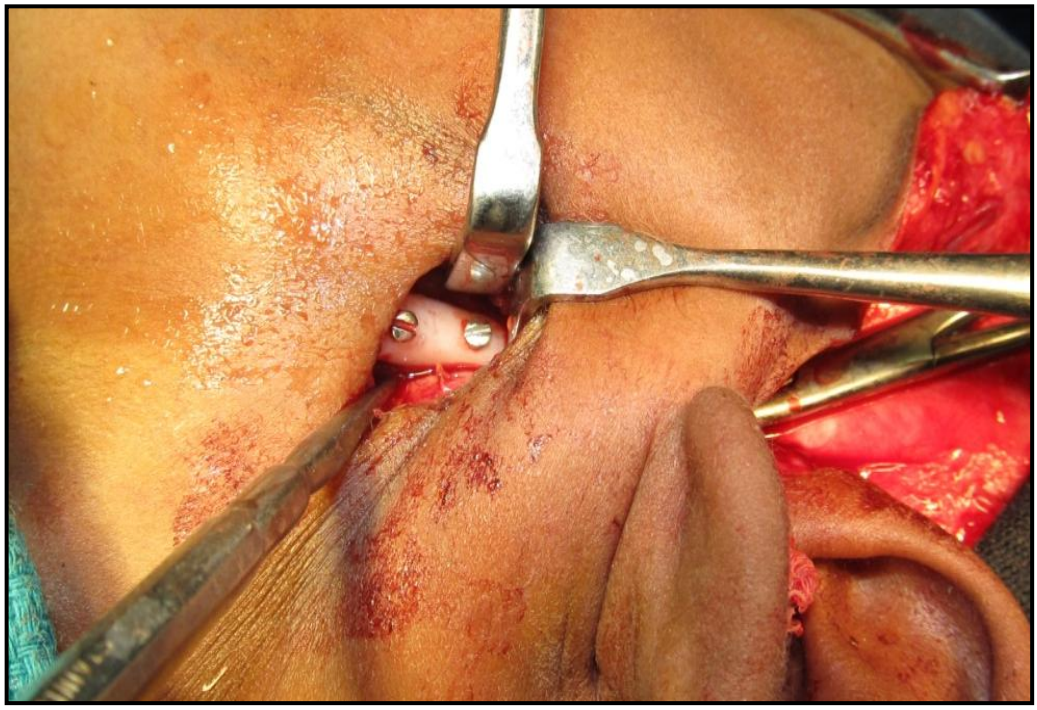
STEP I: SUBMANDIBULAR INCISION

ADAPTATION OF GRAFT TO NEWLY CREATED

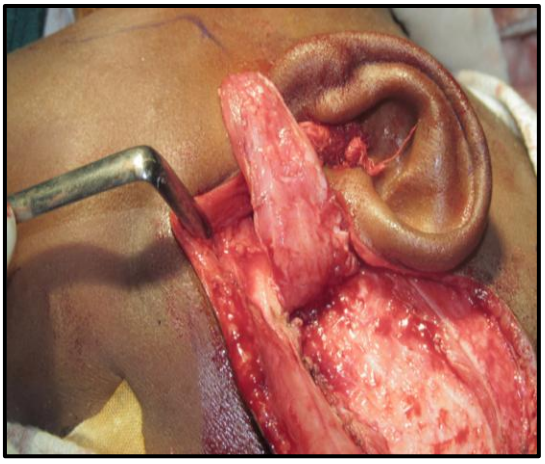
GLENOID FOSSA

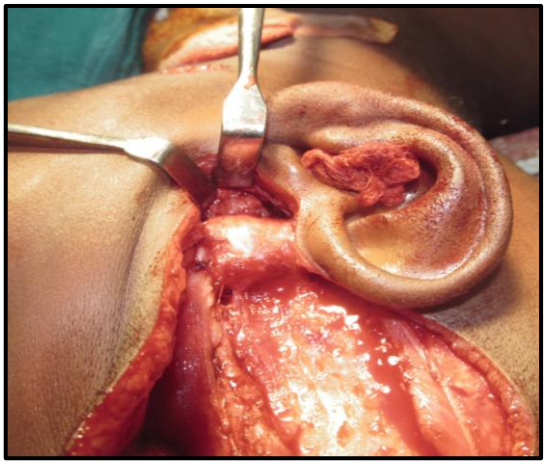


FIXATION OF GRAFT



INTERPOSITIONING TEMPORALIS FASCIA





WOUND CLOSURE

POSTOPERATIVE CARE:

ARM SLING

PHYSIOTHERAPY USING HEISTER JAW OPENER

Case reports

CASE REPORT-1

Name: Master Narasimhan

Age: 11 Years

Sex: Male

Chief complaint: inability to open the mouth since 6 years

History of present illness: h/o fall four years back after which there was progressive decrease in mouth opening .

Past medical, surgical history: nothing significant

General examination: moderateraly nourished,no signs of pallor, clubbing, jaundice, pedal oedema

Clinical examination:

Extra oral:

- facial asymmetry with deviation of chin to the left side
- micrognathia
- microgenia
- condylar movements not palpable on the left side
- lateral excursions not possible towards the right
- prominent antegonial notch on the left side
- maximum incisor opening: 6 mm

Intraoral:

- devation of midline to the left
- class ii malocclusion on left side

Investigations:

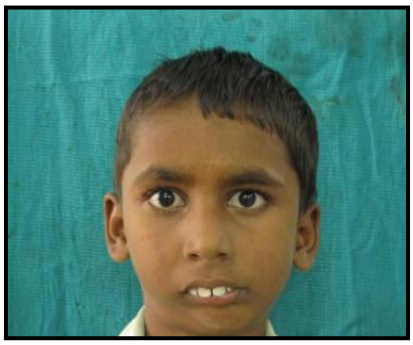
- OPG
- CT SCAN-axial,coronal and 3-d reconstruction

- PA VIEW CHEST
- PA CEPHALOGRAM
- LATERAL CEPHALOGRAM

RADIOGRAPHIC EXAMINATION: there was a bony continuity from base of the skull at the root of zygomatic arch to condylar neck and coronoid hypertrophy on the left side

Provisional diagnosis: unilateral TMJ ankylosis (left side)

PRE-OPERATIVE FRONTAL VIEW



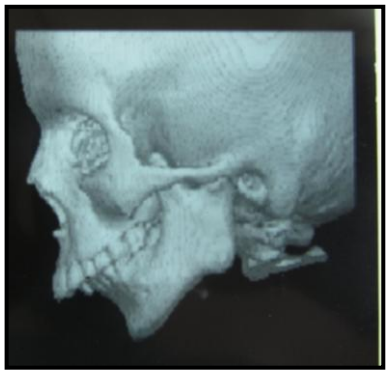
POST-OPERATIVE MOUTH OPENING:

Pre-Operative

Post-Operative

PRE-OPERATIVE CT

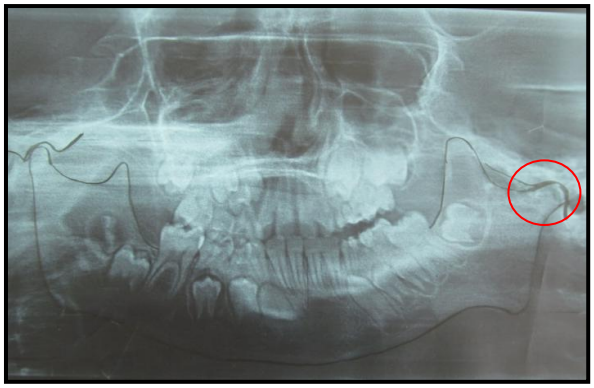
Coronal view



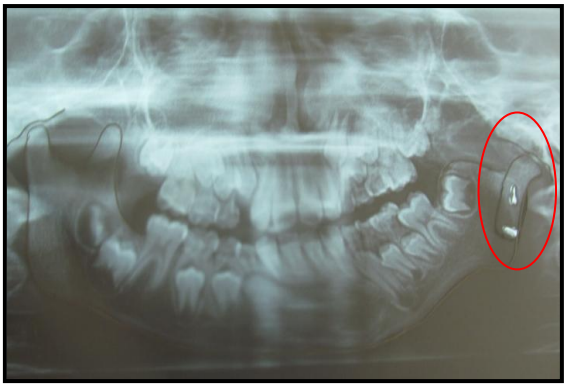
3D CT Scan

OPG

Pre –operative:

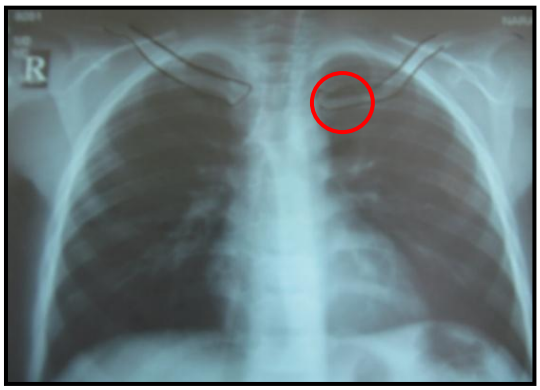


Post-operative:

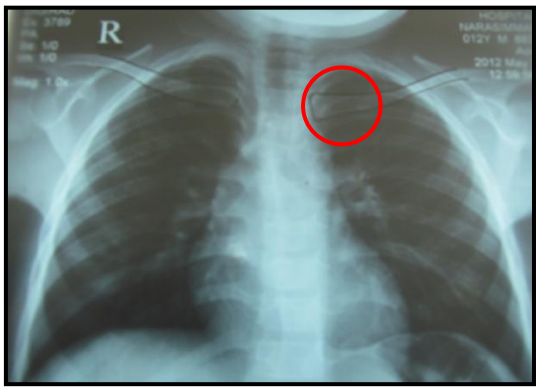


POST OPERATIVE CHEST X-RAY

After 1 Week



After 6 Months



CASE REPORT-2

Name: Rhindiya

Age: 10 Years

Sex: Female

Chief complaint: inability to open the mouth since 7 years

History of present illness: h/o infection in the ear when the patient was one month old and had undergone surgery for the same .after that there was progressive decrease in mouth opening . and had undergone surgery for tmj ankylosis when she was 3 years old and had normal mouth opening for 6 months only after which there was progressive decrease in mouth opening as she did not continue with physiotherapyand came to nil mouth opening since then.

Past medical, surgical history: had undergone surgery for ear infection when she was one month old and for tmj ankylosis at 3 years of age

General examination: moderateraly nourished, no signs of pallor, clubbing, jaundice, pedal oedema

Clinical examination:

Extra oral:

- facial asymmetry with deviation of chin to the right side
- micrognathia
- microgenia
- condylar movements not palpable on right side
- lateral excursions not possible towards the left
- prominent antegonial notch on the right side
- maximum incisor opening: nil

Intraoral:

- Devation of midline to the right
- Class ii malocclusion on right

Investigations:

- OPG
- CT SCAN-axial, coronal and 3-d reconstruction
- PA view chest
- PA cephalogram
- Lateral cephalogram

RADIOGRAPHIC EXAMINATION: there was a bony continuity from base of the skull at the root of zygomatic arch to condylar neck on the right side with coronoid hypertrophy

Provisional diagnosis: unilateral recurrent TMJ ankylosis (right side)

CASE REPORT-2

Name: Rhindiya

Age: 10 Years

Sex: Female

Chief complaint: inability to open the mouth since 7 years

History of present illness: h/o infection in the ear when the patient was one month old and had undergone surgery for the same .after that there was progressive decrease in mouth opening . and had undergone surgery for tmj ankylosis when she was 3 years old and had normal mouth opening for 6 months only after which there was progressive decrease in mouth opening as she did not continue with physiotherapyand came to nil mouth opening since then.

Past medical, surgical history: had undergone surgery for ear infection when she was one month old and for tmj ankylosis at 3 years of age

General examination: moderateraly nourished, no signs of pallor, clubbing, jaundice, pedal oedema

Clinical examination:

Extra oral:

- facial asymmetry with deviation of chin to the right side
- micrognathia
- microgenia
- condylar movements not palpable on right side
- lateral excursions not possible towards the left
- prominent antegonial notch on the right side
- maximum incisor opening: nil

Intraoral:

- Devation of midline to the right
- Class ii malocclusion on right

Investigations:

- OPG
- CT SCAN-axial, coronal and 3-d reconstruction
- PA view chest
- PA cephalogram
- Lateral cephalogram

RADIOGRAPHIC EXAMINATION: there was a bony continuity from base of the skull at the root of zygomatic arch to condylar neck on the right side with coronoid hypertrophy

Provisional diagnosis: unilateral recurrent TMJ ankylosis (right side)

CASE REPORT-2

Name: Rhindiya

Age: 10 Years

Sex: Female

Chief complaint: inability to open the mouth since 7 years

History of present illness: h/o infection in the ear when the patient was one month old and had undergone surgery for the same .after that there was progressive decrease in mouth opening . and had undergone surgery for tmj ankylosis when she was 3 years old and had normal mouth opening for 6 months only after which there was progressive decrease in mouth opening as she did not continue with physiotherapyand came to nil mouth opening since then.

Past medical, surgical history: had undergone surgery for ear infection when she was one month old and for tmj ankylosis at 3 years of age

General examination: moderateraly nourished, no signs of pallor, clubbing, jaundice, pedal oedema

Clinical examination:

Extra oral:

- facial asymmetry with deviation of chin to the right side
- micrognathia
- microgenia
- condylar movements not palpable on right side
- lateral excursions not possible towards the left
- prominent antegonial notch on the right side
- maximum incisor opening: nil

Intraoral:

- Devation of midline to the right
- Class ii malocclusion on right

Investigations:

- OPG
- CT SCAN-axial, coronal and 3-d reconstruction
- PA view chest
- PA cephalogram
- Lateral cephalogram

RADIOGRAPHIC EXAMINATION: there was a bony continuity from base of the skull at the root of zygomatic arch to condylar neck on the right side with coronoid hypertrophy

Provisional diagnosis: unilateral recurrent TMJ ankylosis (right side)

CASE REPORT-3

Name: Master Sabarirajan

Age: 9 Years

Sex: Male

Chief complaint: inability to open the mouth since three years

History of present illness: h/o fall four years back after which there was progressive decrease in mouth opening .

Past medical, surgical history: nothing significant

General examination: moderateraly nourished, no signs of pallor, clubbing, jaundice, pedal oedema

Clinical examination:

Extra oral:

- facial asymmetry with deviation of chin to the right side
- micrognathia
- microgenia
- condylar movements not palpable on the right side
- lateral excursions not possible towards the left
- prominent antegonial notch on the right side
- maximum incisor opening: 10mm

Intraoral:

- devation of midline to the right
- class ii malocclusion on right side

Investigations:

- OPG
- CT SCAN-axial,coronal and 3-d reconstruction

- PA view chest
- PA cephalogram
- Lateral cephalogram

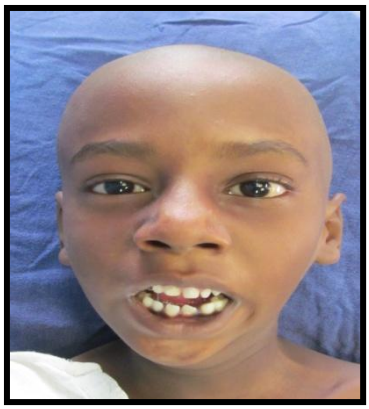
RADIOGRAPHIC EXAMINATION: there was a bony continuity from base of the skull at the root of zygomatic arch to condylar neck .

Provisional diagnosis: unilateral TMJ ankylosis(right side)

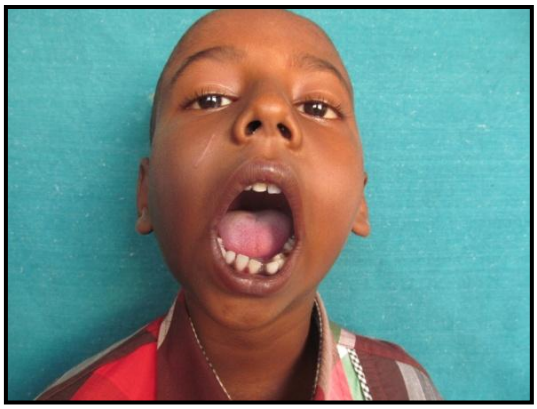
PRE-OPERATIVE FRONTAL VIEW

MAXIMUM INCISOR OPENING:

Preoperative:

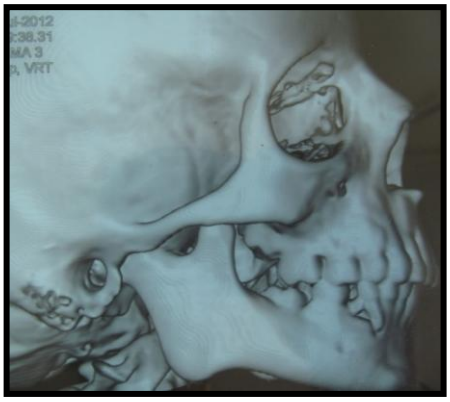


Post operative:



PREOPERATIVE CT

Coronal view

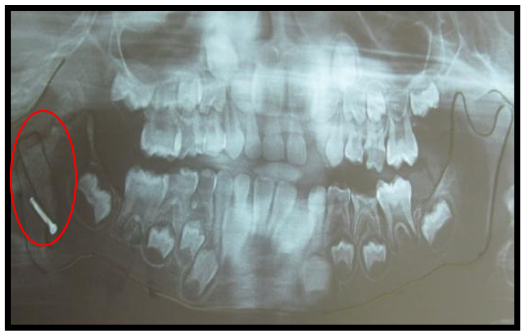


3D CT Scan

OPG:

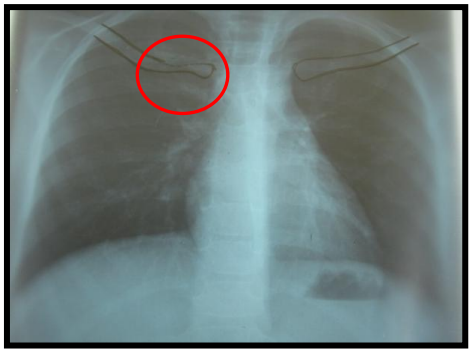
Pre-operative:

Post-operative:

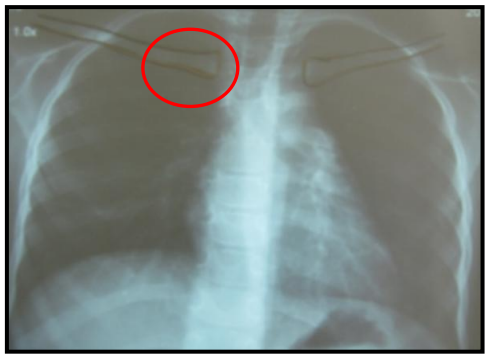


POSTOPERATIVE CHEST X-RAY:

After 1 Week



After 6 Months



CASE REPORT-4

Name: Master Thirumoorthy

Age: 16 Years

Sex: Male

Chief complaint: inability to open the mouth since one and half years

History of present illness: h/o fall four years back after which there was progressive decrease in mouth opening .he had undergone surgery for tmj ankylosis in 2010 after which there was and had normal mouth opening for 6 months only after which there was progressive decrease in mouth opening as he did not continue with physiotherapy and hence there was progreesive decrease in mouth opening since then.

Past medical,surgical history: had undergone surgery fotr TMJ ankylosis 2 years back.

General examination: moderateraly nourished,no signs of pallor, clubbing, jaundice, pedal oedema

Clinical examination:

Extra oral:

- facial asymmetry with deviation of chin to the left side
- micrognathia
- microgenia
- condylar movements not palpable on the left side
- lateral excursions not possible towards the right
- prominent antegonial notch on the left side
- maximum incisor opening: 6 mm

Intraoral:

- devation of midline to the left
- class I occlusion on left and right side

Investigations:

- OPG
- CT SCAN-axial,coronal and 3-d reconstruction
- PA VIEW CHEST
- PA CEPHALOGRAM
- LATERAL CEPHALOGRAM

RADIOGRAPHIC EXAMINATION: there was a bony continuity from base of the skull at the root of zygomatic arch to condylar neck and coronoid hypertrophy on the left side

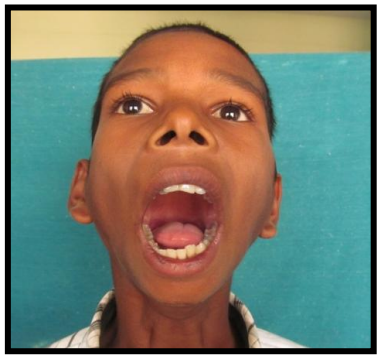
Provisional diagnosis: unilateral TMJ ankylosis(left side)

PRE-OPERATIVE FRONTAL VIEW

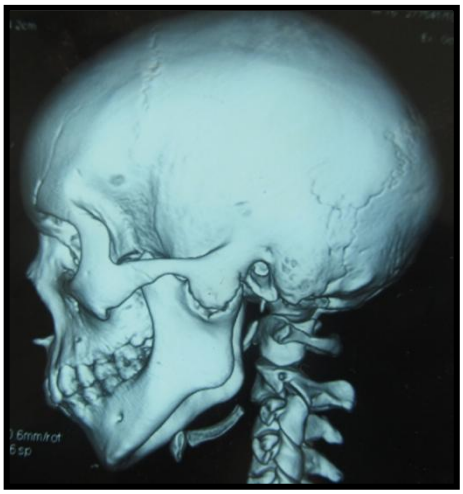
MAXIMUM INCISOR OPENING

Preoperative

Postoperative



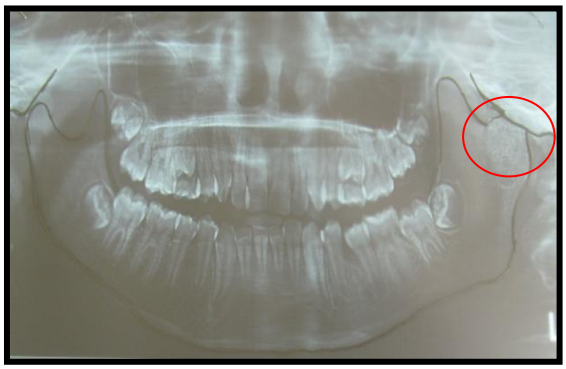
PREOPERATIVE CT:



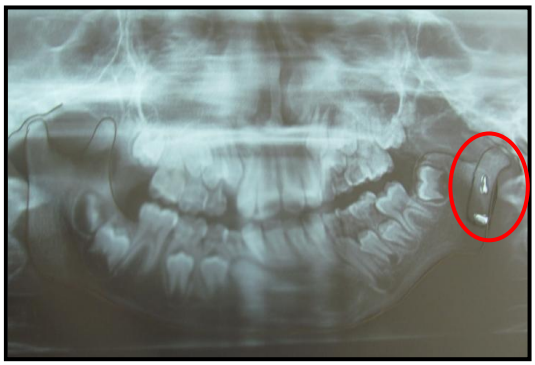
3D CT Scan

OPG

Pre-Operative

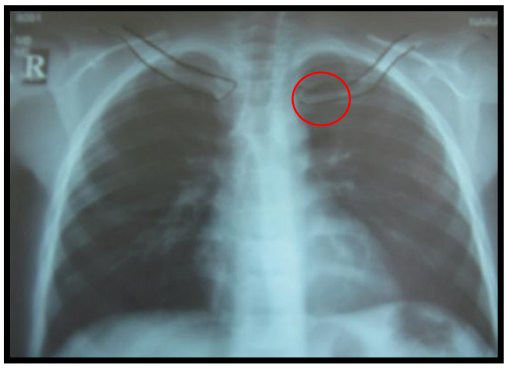


Post-Operative

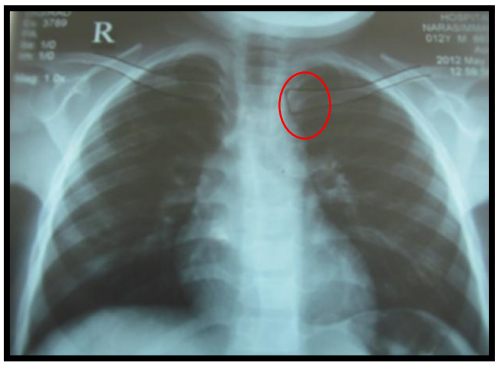


POST-OPERATIVE CHEST X-RAY

After one week



After 6 months:



CASE REPORT -5

Name: master Thangaraj

Age: 14 Years

Sex: Male

Chief complaint: inability to open the mouth since one year

History of present illness: h/o fall one and halfyears back in and had left condylar fracture and was kept in imf for 2 weeks after the release of imf there was progressive decrease in mouth opening .

Past medical,surgical history: nothing significant

General examination: moderateraly nourished,no signs of pallor, clubbing, jaundice, pedal oedema

Clinical examination:

Extra oral:

- facial asymmetry with deviation of chin to the left side
- micrognathia
- microgenia
- condylar movements not palpable on the left side
- lateral excursions not possible towards the right
- prominent antegonial notch on the left side
- maximum incisor opening: 6 mm

Intraoral:

- devation of midline to the left
- class ii malocclusion on left side

Investigations:

- OPG
- CT SCAN-axial,coronal and 3-d reconstruction
- PA VIEW CHEST
- PA CEPHALOGRAM
- LATERAL CEPHALOGRAM

RADIOGRAPHIC EXAMINATION: there was a bony continuity from base of the skull at the root of zygomatic arch to condylar neck and coronoid hypertrophy on the left side.

Provisional diagnosis: unilateral TMJ ankylosis(left side)

PRE-OPERATIVE FRONTAL VIEW

MAXIMUM INCISOR OPENING

Preoperative

Post-Operative

PRE –OPERATIVE CT

3D CT Scan

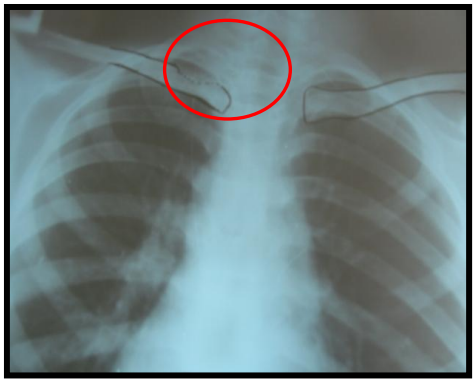
OPG:

Preoperative:

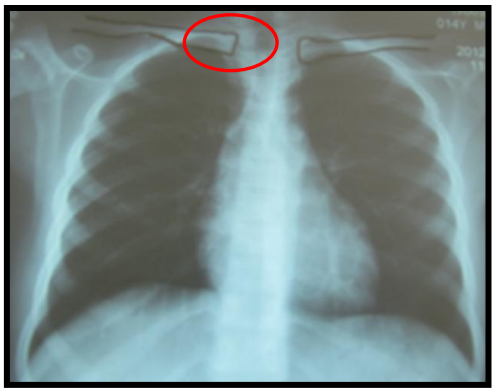
Post operative:

POST-OPERATIVE CHEST X-RAY

After one week:



After 6 months:



Observation

& Results

OBSERVATION AND RESULTS

In this study 5 patients with unilateral TMJ ankylosis in the age group of 10-20 years were evaluated with a follow up period of 6 months. The parameters assessed were:

- Pre-operative, intraoperative and postoperative maximum incisor opening,
- Pre-operative Lateral and protrusive movements,
- Pre-operative and postoperative cephalometric, measurement of ramus height and body length,
- Pre and post operative radiographic analysis of graft in relation to glenoid fossa and ramus of mandible,
- Pre operative, immediate postoperative and after 6 months postoperative analysis of donor site regeneration using chest x-ray, & P.A.View,
- Pre-operative mouth opening was 0-10mm (mean-2mm), intraoperatively the mouth opening achieved were 28-32mm (mean-29.6mm) post-operatively after 6 months there was progressive decrease in mouth opening in one patient from 30mm to 26mm whereas the remaining four patients had an increase in mouth opening from 30-35mm (mean 32.6mm). There was significant improvement in protrusive and lateral movements of the jaws. There was no change in body length pre and postoperatively, and increase of 2-5mm in the ramal height was observed pre and postoperatively.

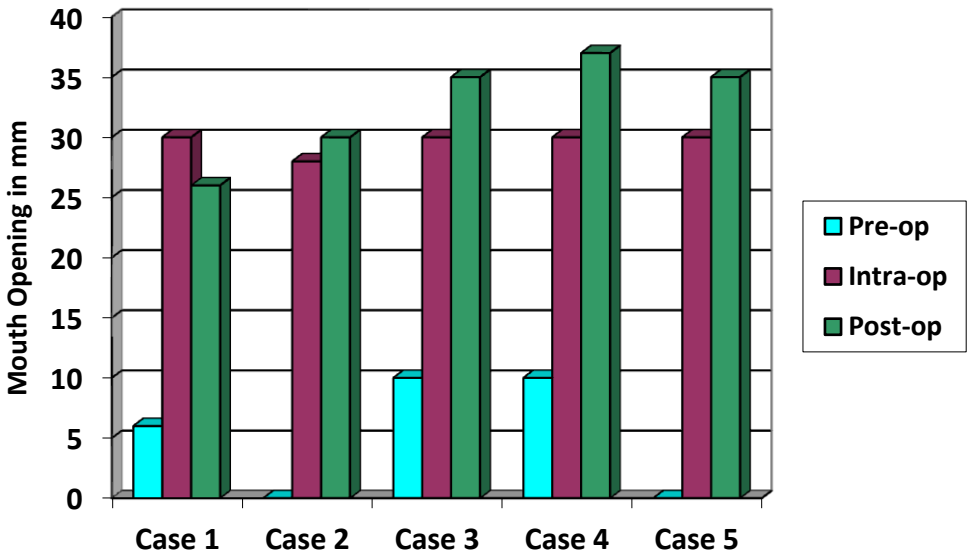
There was no change in the midline deviation. There was no evidence of facial nerve paresis, wound infection, clavicular fracture and there was no evidence of any donor site morbidity with no pain in the clavicle. The shoulder movements were

normal after 3 months. There was no signs of graft rejection in all patients There was however the presence of scar was evident in the clavicular region in all the five patients.

Radiological analysis showed regeneration of clavicle in the five patients with gradual adaptation of the graft to the newly created glenoid fossa.

Comparison of maximum incisor opening preoperative, Intraoperative, post-operative after 6 months:

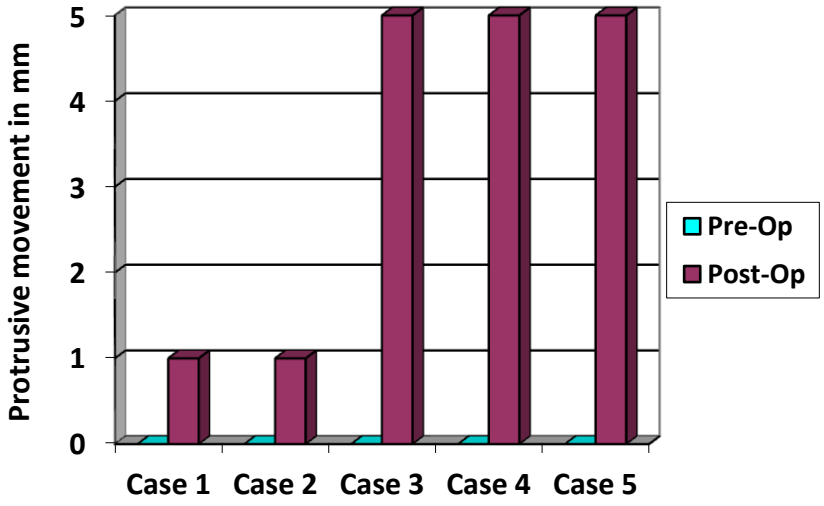
S. No	Age/Sex	Etiology	Ankylosis side	Maximum incisor opening		
				Pre Op	Intra Op	Post Op
1	11/M	Trauma	Lt	6mm	30mm	26mm
2	10/F	Infection	Rt	0mm	28mm	30mm
3	10/M	Trauma	Rt	10mm	30mm	35mm
4	16/M	Trauma	Lt	10mm	30mm	37mm
5	14/M	Trauma	Lt	0mm	30mm	35mm



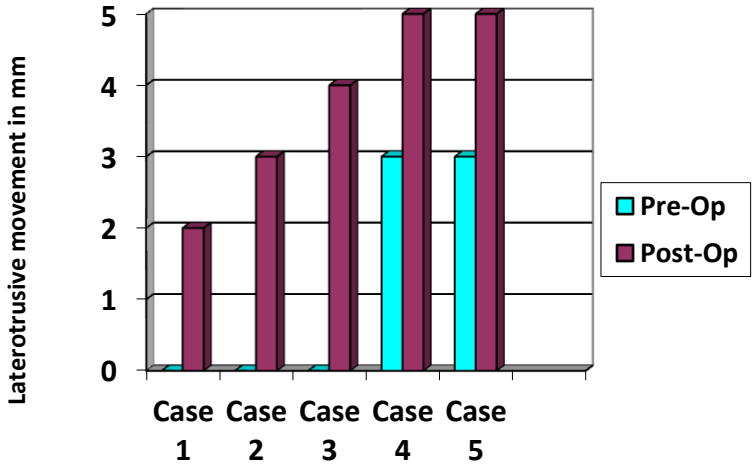
X Axis – Case No ***Y Axis – Mouth opening in mm***

Comparison of Protrusive and laterotrusive movements preoperative and postoperative

S. No	Age	Sex	Protrusive-mm		Laterotrusive	
			Preoperative	Postoperative	Preoperative	Post Operative
1.	11	M	0	1	0	2
2.	10	F	0	1	0	3
3.	10	M	0	3	2	4
4.	16	M	0	3	3	5
5.	14	M	0	3	3	5



X Axis – Case No ***Y Axis – Protrusive movements in mm***



X Axis – Case No ***Y Axis – Laterotrusive movement in mm***

Radiographic assessment of the graft in relation to glenoid fossa and donor site morbidity :

S. No	Graft in relation to glenoid fossa	Donor Site
1	Good adaptation to glenoid fossa	Complete regeneration of clavicle
2	Good adaptation to glenoid fossa	Complete regeneration of clavicle
3	Good adaptation to glenoid fossa	Complete regeneration of clavicle
4	Good adaptation to glenoid fossa	complete regeneration of clavicle
5	Good adaptation to glenoid fossa	complete regeneration of clavicle

Cephalogram measurements:

S. No	Ramus Height:		Body length:	
	Pre Operative	PostOperative	Pre Operative	Postoperative
1.	51mm	55mm	72mm	72mm
2.	54mm	57mm	75mm	75mm
3.	52mm	54mm	80mm	80mm
4.	53mm	55mm	76mm	76mm
5.	50mm	55mm	82mm	82mm

Discussion

DISCUSSION

TMJ ankylosis is an incapacitating condition causing complex problems such as inability to open the mouth, difficulty in chewing, speech impairment, facial asymmetry, airway compromise as well as a psychological stress to the patients.

The main aims of treatment of TMJ ankylosis are:

1) To restore adequate mouth opening and functional range of motion.
2) To establish the ramus height for maintenance of vertical dimension improvement of existing occlusion and avoidance of post operative mal occlusion.
3) To provide unhindered growth of the mandible thereby restoring facial symmetry.
4) To avoid re-ankylosis.[87]

The surgical procedure for TMJ ankylosis can be either a condylectomy alone, or a gap arthroplasty or interpositional arthroplasty.

Esmarch in 1851 performed the first osteotomy for TMJ ankylosis however the first condylectomy was done by Humpherey in 1854 and it was Abbe in 1880 who first introduced the gap arthroplasty.[2]

Later on in 1934, Risdon used an interpositional material.[96]The rationale behind the placement of an interpositional material was that it forms a partition between bony compartments, similar to an articular disc. However the recurrence rate was high in the study by Topazian (53%) using interpositional arthroplasty.[116] Moreover the interpositional material failed to restore adequate ramal height. In this study unilateral ankylosis cases were considered for case selection and all the patient

were treated with Gap arthroplasty, joint reconstruction, followed by interposition of temporalis myofascial flap.

Controversies exist regarding the timing of surgery for TMJ ankylosis. Proponents of functional matrix theory by Melvin Moss advocated to relieve ankylosis as early as possible since an early mobilization stimulates bone growth. According to functional matrix theory the condyle is not a primary growth center but just an adaptive center whereby the secondary cartilage reacts to translational movement of the mandible by growing to keep contact with glenoid fossa[75]. Hence in ankylosis, absence of translational movements leads to failure of condylar and ramal growth and therefore early release of ankylosis and reconstruction with an autogenous graft to permit an adaptive growth is necessary.

The other reason for reconstructing a condyle with autogenous grafts is that a normal mandible is basically a class 3 lever with condyle as the fulcrum of rotation, the elevator muscle the working force and food bolus as resistance force , so is in case of a condylectomy or gap arthroplasty with or without interpositional material this third class lever is converted to a first class lever. The most posterior tooth which occludes with the upper jaw becomes the fulcrum and the mandible in turn rotates upwards and posteriorly leading to an open bite in bilateral cases[87]. Unilateral TMJ ankylosis presents with, a short ramus, flat gonial angle, deviation of chin to affected side and hence there is a need to provide a graft with growth capacities similar to normal condyle.

Autogenous graft or alloplastic materials have been used by many surgeon's to reconstruct the TMJ. The disadvantages of alloplastic material are wear and tear of the

material, foreign body reactions, loosening of the implant, or displacement, fracture, high cost, dystrophic bone formation, lack of growth potential in children.

Inspite of having drawbacks such as donor site morbidity, infection, failure of uptakes, autogenous grafts have been still widely used for TMJ reconstruction. The various autogenous grafts used are costochondral[30,87,90], sternoclavicular[95,105,107,122,126], metatarsal, iliac crest, fibula, coronoid. Transport distraction osteogenesis have also been attempted for reconstructing a resected condyle and distraction osteogenesis for correction of secondary deformity due to TMJ ankylosis.

The most widely used autogenous graft costochondral graft was first described by Harold Gilles (1920)[30], however the current technique was popularised by Poswillo[90]. CCG is a biologically compatible, easily workable adapts into the new environment, there is a potential for the donor site to grow or regenerate.

Costochondral grafts have many drawbacks such as impredictable growth, flexibility and elasticity of bone, warpage with continous loading, poor quality of medullary and cortical bone, possibility of resorption and infection, possible separation of cartilage from the bone and the donor site complications such as pleural tear, pnuemothorax, pleural effusion have made us to search for an alternative and the sternoclavicular graft which resembles the TMJ morphologically and histologically could be a viable option[107].

Snyder *et al* reported using first Sterno clavicular whole joint graft consisting of manubrium, with capsule and a portion of clavicle on a 70 year old man with

cylindroma[110]. Ried *et al* reported a free flap technique that included the clavicular head of pectoralis major and overlying skin to provide a vascularised free graft.[95]

Seimssen (1982) used clavicle pedicled on clavicular head of sterno mastoid muscle as a graft for TMJreconstruction[105].

Ellis and Carlson (1986) did a histologic comparison of costochondral, sterno clavicular and TMJ during growth in Macaca Mullatta and found that the TMJ and SCJ are very similar morphologically throughout the growth period and that the clavicular head had layers of cartilage typical to the mandibular condyle, However the CCJ did not resemble the condyle but rather appeared similar to growth plate in a long bone epiphysis during growth and concluded that SCJ may be more suitable for mandibular condyle replacement[24].

Sarnet and Laskin stated that SCJ and TMJ are similar anatomically and physiologically. The SCJ articulation has a growth centre, interarticular fibro articular disc that simulates the disk of the TMJ.

Daniel *et al* showed that when placed to reconstruct the TMJ, SCJ graft undergoes remodeling and resemble the native condyle unlike CCG which does not.[12] Wolford *et al* observed an improved fit when only the superior half of the clavicle was used. The graft can be placed on the lateral, along the posterior border or medial side, decortication can be done on the lateral aspect of ramus and multiple holes can be made in the graft for better revascularization and adaptation.

And reported a success rate of 93% in patients with non proplast Teflon prosthesis and non inflammatory TMJ pathology in using SCJ for TMJ construction. He found that using the contralateral clavicle for the donor and placing the graft at the posterior border provided the best fit. When placing the graft in the lateral or medial side reshaping of the long axis of clavicular head is needed for an accurate fit. The donor site morbidity included fractures of clavicles in 10 %. He concluded that the technique of removing only the superior half of clavicle had an improved fit, there was reformation of removed bone, revascularization may be easier because of direct exposure of medullary bone of the graft to adjacent soft tissues however in children under 5 years, full thickness graft is recommended because of the small size of clavicle[126].

Hence the advantages of a SCG are,

- Resemblance to the TMJ both morphologically and histologically.
- Provides an adaptive growth centre.
- Significant strength and hence sufficient strength can be accomplished to create a stable vertical and anterior repostioning of the mandible.
- Rigid fixation can be used and jaw function instituted immediately.
- Adequate revascularization decreasing the chance of avascular necrosis.
- Minimal donor site morbidity as there is a complete regeneration of clavicle at the donor site.

However inspite of being a benign procedure because of its superficial location but the surgery is comparatively complex and there can be damage to the great vessels at time of harvest. Post operatively instability of clavicle may lead to

shoulder instability or even clavicular fractures. Some times non union or malunion of clavicular fractures impinging on the brachial plexus has been reported and a hyper trophic scar seen may be displeasing to esthetically concious patients.

In this study patients above 10 years were chosen as the clavicular thickness below 10years precludes the use of split thickness graft where a full thickness graft would be the option. It was also noted that the split thickness graft comprising of the superior half of the clavicle better fitted into the newly created glenoid fossa similar to wolfords study.

There was a complete regeneration of clavicle minimizing donor site morbidity in all patients similar to v.singh *et al* studies. Moreover the use of temporalis fascia as an interposing material had an added advantage of reducing the chance of reankylosis as it minimizes bone to bone contact.

The post operative complications were nil in all the five cases except for a mild scar in the donor site, which was acceptable. The postoperative mouth opening was highly satisfied with a maximum mouth opening of more than 30mm except in one case which was managed by vigourous physiotherapy. The growth of the reconstructed TM joint was evaluated with orthopantomogram, & CT Scan. The complete regeneration of the SCG was also observed with chest xray.

The reconstruction of TMJ with SCG has been proved to be successful in this study, as it has been mentioned in various literature, by many authors.

Summary &Conclusion

SUMMARY AND CONCLUSION

TMJ ankylosis is one of the most physically incapacitating and psychologically distressing conditions of the TMJ. Various treatment modalities have been proposed for treatment of TMJ ankylosis each having its own merits and demerits. The comparison of the reported treatment modalities have enlightened us the success, the difficulty and complications in each procedure but at the same time they have differing periods of follow up with different definitions of success.

The most favoured autogenous graft has long been the costochondral graft for reconstruction of ramus condyle unit but the unpredictable growth pattern of the CCG has made us to search for a better alternative. Literature revealed that the sternoclavicular joint resembled the TMJ morphologically and histologically.

In this study 5 patients who reported to our deparment with TMJ ankylosis were treated with sternoclavicular graft for TMJ reconstruction. Our results revealed that there was anatomic resemblance of the SCG to the TMJ and there was no donor site morbidity as there was regeneration of clavicle at the donor site.

The mouth opening was normal (more than 30mm) in all the cases during the follow up period after the reconstruction of the TMJ with SCG. Moreover the patients were subjectively satisfied with the outcome of the results. It is important to note that the psychological inhibition which was present before surgery is entirely alleviated.

With an impressive success rate, the sternoclavicular graft could become a versatile and viable alternative to the surgeons in reconstruction of TMJ as it is relatively simple to carry out with minimal complications and good results.

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Annexure

ANNEXURE

சுய ஒப்புதல் படிவம்
ஆய்வு செய்யப்படும் தலைப்பு

மார்பு கழுத்தெலும்பு சார் மூட்டை ஒட்டாக பொட்டெலும்பு கீழ்தாடை சார் மூட்டெலும்பு பிணைப்பை நீக்கி பொருத்துதல்

ஆராய்ச்சி நிலையம் : அரசு பல் மருத்துவக்கல்லூரி,
சென்னை–600 003.

பங்குபெறுபவரின் பெயர் :
பங்குபெறுபவரின் எண் :
பங்கு பெறுபவரின் பிறந்த தேதி : ...../...../.....
தேதி மாதம் வருடம்

அறுவை சிகிச்சை சம்பந்தமாக நான் மேலே கூறப்பட்ட தகவல் படிவத்தை முழுமையாக படித்துப்பார்த்தேன் என்று உறுதி கூறுகிறேன்.

நான் இது தொடர்பான அனைத்து கேள்விகளுக்கும் நிறைவான பதில்கள் பெறப்பட்டேன்.

இந்த ஆய்வின் எனது பங்கு தன்னிச்சையானது என்றும் எந்த நேரத்திலும் இந்த ஆய்வில் இருந்து சட்ட உரிமைகள் பாதிக்கப்படாமல் விலகிக் கொள்ள சம்மதிக்கிறேன்.

மருத்துவ ஆய்வு அதிகாரிகள், எனது சிகிச்சை தொடர்பான பதிவேடுகளை பார்வையிடவும் எந்த நேரத்திலும், ஆய்வில் இருந்து நான் விலகினாலும் பார்வையிட சம்மதிக்கிறேன். எனது அடையாள குறிப்புகள் மூன்றாவது நபருக்கு தெரிவிக்கப்படமாட்டாது என்று புரிந்து கொண்டேன்.

இந்த ஆய்வு அறிக்கைகளை பயன்படுத்தவும், வெளியிடவும், நான் சம்மதிக்கிறேன். ஆய்வாளர் எனது மருத்துவக் குறிப்புகளை வெளியிட தடையாக இருக்க மாட்டேன் என உண்மையாக சம்மதிக்கிறேன்.

நான் இந்த ஆய்வுக்கு முன்னர் கூறிய மருத்துவ குறிப்புகளின்படியும் உண்மையாக சம்மதிக்கிறேன். மேலும் எனக்கு உடல்நிலை சரியில்லாத பட்சத்தில் ஆய்வாளருக்கு தெரியப்படுத்த சம்மதிக்கிறேன்.

பொது உணர்வகற்றல் மருத்துவ முறையின் மூலம் எனது காதின் முன்புறம் அறுவை சிகிச்சைகான வெட்டுகீறல் மூலமாக எனது பொட்டெலும்பு, கீழ்தாடை சார் மூட்டில் உள்ள எலும்பு பிணைப்பை அகற்றி, அங்கு எனது மார்பு கழுத்தெலும்புசார் மூட்டை உலோக தகடுகள், முறுக்காணி மூலமாக ஒட்டப்படுகிறது என்பதை நான் அறிந்து கொண்டேன். இந்த அறுவை சிகிச்சை முறையில் ஏற்படும் அனைத்து பக்கவிளைவுகளையும் மருத்துவர் மூலம் அறிந்து கொண்டு இந்த ஆய்விற்கு என்னை உட்படுத்திக்கொள்கிறேன்.

நான் எனது மருத்துவ குறிப்புகளை தரவும், மேலும் முப உடல் பரிசோதனைக்கும் இரத்தம், சிறுநீர் மற்றும் உயிர் வேதியியல் நோய் அறிதல் சோதனைகளுக்கும் முழு ஒப்புதல் அளிக்கிறேன்.

பங்கேற்பவரின் கையொப்பம் ..... இடம் ..... தேதி
கட்டைவிரல் ரேகை
பங்கேற்பவரின் பெயர் மற்றும் விலாசம் .....
ஆய்வாளரின் கையொப்பம் ..... இடம் ..... தேதி
ஆய்வாளரின் பெயர் .....

CASE REPORT FORM

STERNOCLAVICULAR GRAFT FOR TEMPOROMANDIBULAR JOINT RECONSTRUCTION IN UNILATERAL TMJ ANKYLOSIS

Patient's Name : _____

Age/ Sex : _____

Patient's Identification No. : _____

Contact Address : _____

_____

Contact No : _____

Institution : TN Govt. Dental College & Hospital, Chennai - 600 003.

Centre : Dept. of Oral & Maxillofacial Surgery, TN. Govt. Dental College and Hospital, Chennai - 600 003.

Patient's Identification/ OP. No. _____ Date: _____

Details of Surgery

Procedure followed : TMJ ankylosis release and interpositional arthroplasty with sternoclavicular graft

Duration of Surgery :

Any other information :

Details of Drug therapy :

Name of the Investigator :

Signature of Investigator :

INFORMED CONSENT

STERNOCLAVICULAR GRAFT FOR TMJ RECONSTRUCTION IN UNILATERAL TMJ ANKYLOSIS

Patient's Identification No: _____ Patient's Name: _____

Patient's DOB:_____ dd _____ mm_____yyyy

I confirm that I have read and understood the Information Sheet for the above study. I have had the opportunity to ask questions and all my questions and doubts have been answered to my complete satisfaction.

I understand that my participation in the study is voluntary and that I am free to withdraw at any time, without giving any reason, without my legal rights being affected.

I understand that the Clinical study personnel, the Ethics Committee and the Regulatory Authorities will not need my permission to look at my health records both in respect of the current study and any further research that may be conducted in relation to it, even if I withdraw from the study. I agree to this access. However, I understand that my identity will not be revealed in any information released to the third parties or published, unless as required under the law. I agree not to restrict the use of any data or results that arise from this study.

I agree not to withhold any information about my health from the investigator and will convey the same truthfully.

I agree to take part in the above study and to comply with the instructions given during the study and to faithfully co-operate with the study team and to immediately inform the study staff if I suffer from any deterioration in my health or well being or any unexpected or unusual symptoms.

I hereby consent to participate in this study & I understand that I'll be treated by surgical procedure under general anaesthesia for my facial deformity & inability to open the mouth and I was well informed about the complications associated with it & I agree for the same.

I consent to give my medical history, undergo complete physical examination and diagnostic tests including hematological, biochemical and urine examination etc.

Signature / Thumb Impression: _____ Place_____Date_____

Patient's Name & Address: _____

_____

Signature of the Investigator: _____Place_____ Date_____

Study Investigator's Name: _____

Institution: _____

* Signature of the Witness: _____Place_____ Date_____

* Name & Address of the Witness _____

_____ *Mandatory for uneducated patients (Where thumb impression has been provided above)

CASE SHEET PROFORMA:

NAME:

AGE:

CHIEF COMPLAINT:

HISTORY OF PRESENT ILLNESS:

HISTORY OF DRUG ALLERGY:

PAST MEDICAL HISTORY:

PAST SURGICAL HISTORY:

PAST DENTAL HISTORY:

PERSONAL HISTORY:

FAMILY HISTORY:

GENERAL EXAMINATION:

LOCAL EXAMINATION:

EXTRA ORAL EXAMINATION:

INTRA ORAL EXAMINATION:

INVESTIGATIONS:

- Complete hemogram
- Chest x-ray
- Opg
- PA cephalogram
- Lateral cephalogram
- Ct scan

PROVISIONAL DIAGNOSIS:

TREATMENT PLAN: